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UNITED STATES DEPARTMENT OF AGRICULTURE
BULLETIN No. 932
Contribution from the Bureau of Entomology
L. O. HOWARD, Chief

Washington, D. C. PROFESSIONAL PAPER September 20, 1921

LIFE HISTORY OF THE CODLING MOTH IN THE GRAND VALLEY OF COLORADO

By

E. H. SIEGLER, Entomologist, and H. K. PLANK, Scientific Assistant, Fruit Insect Investigations, in Cooperation with The Colorado Agricultural Experiment Station

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INTRODUCTION.

The codling moth, *Laspeyresia pomonella* (L.) (Pl. I, A) is generally recognized as the most serious insect pest attacking the fruit of the apple and pear and is particularly abundant and destructive in the Grand Valley of Colorado. As a result of the extensive injury to the fruit industry of this valley for which this insect is responsible, it was deemed desirable to make a thorough study of its life history as a basis for control experiments.

The data reported in the present publication fill an urgent need of long standing for more complete and useful information regarding the seasonal habits of the codling moth in the Grand Valley of Colorado. It should form a basis for constructive control measures for the use of orchardists in this region.

The plans for this investigation were made by the United States Department of Agriculture, Bureau of Entomology, in cooperation with the Colorado Agricultural Experiment Station. The work was done under the general supervision of Dr. A. L. Quaintance, in charge of deciduous fruit insect investigations, Bureau of Entomology, and Prof. C. P. Gillette, director and entomologist of the Colorado Agricultural Experiment Station.

A field station was established at Grand Junction, Colo., in the fall of 1914, by Mr. R. J. Fiske, of the Bureau of Entomology. The senior author was placed in immediate charge of the work in 1915, and was assisted during the year by Mr. E. R. Van Leeuwen, of the Bureau of Entomology, and in 1916 by the junior author. Much valuable information was given from time to time by Messrs. George M. List and Claude Wakeland, of the entomological department of the Colorado Agricultural Experiment Station.

The general character of the work in the Grand Valley was quite similar to that of the codling-moth investigations conducted by the Bureau of Entomology in several other fruit districts, but it was carried out on a somewhat larger scale and includes certain phases of the life history and habits of the codling moth not hitherto reported.

THE GRAND VALLEY OF COLORADO.

LOCATION AND DESCRIPTION.

The Grand Valley of Colorado is located in Mesa County, on the western slope of the Rocky Mountains, is about 32 miles in length, and has an extreme width of 5 miles. It comprises nearly 75,000 acres of land, about one-fifth of which is planted to fruit. At the time of these investigations there were approximately 10,000 acres of apples and about 2,500 acres of pears, while the remainder of the fruited area was devoted chiefly to peaches, plums, cherries, apricots, and bush fruits. The great majority of the orchards, of which the one shown in Plate II is a good example, were planted north of the Grand River, which flows through the entire length of the valley.

TOPOGRAPHY AND ELEVATION.

The valley is comparatively level, with the exception of a few elevations known locally as the "Fruit Ridges." The fruit district of Orchard Mesa, while higher than most other parts of the valley, is typical tableland. The general elevation of the Grand Valley varies from about 4,500 to 4,800 feet, Grand Junction being approximately 4,600 feet above sea level.

CLIMATE.

The climate is relatively dry, the annual rainfall being usually 8 to 9 inches, distributed according to the normal precipitation up to and including 1916 as follows: January 0.49, February 0.64, March 0.71, April 0.76, May 0.92, June 0.40, July 0.50, August 1.04, September 0.95, October 0.91, November 0.55, December 0.44, or a total of 8.31 inches per year. Moisture is supplied the crops by means of irrigation systems, use being made of the water from the Grand River.

The day temperatures during the summer season are high, while those at night are relatively low. For further details as to weather conditions in the Grand Valley see Tables I and II (pp. 4 and 5), which give the annual meteorological summaries of the United States Weather Bureau for the years 1915 and 1916.

EXPLANATION OF TERMS.

In conformity with the previous life-history studies of the codling moth by members of the Bureau of Entomology, certain definitions of the terms employed have been adopted.

The term "generation" is here used to include all the consecutive stages of the codling moth throughout the season, starting with the egg and ending with the adult or moth. Thus the first eggs to be laid (those deposited by the first moths of the season) would start the first generation; these and the resulting larvæ, pupæ, and moths would belong to this generation. The eggs deposited by the moths which belong to the first generation start the second generation, to which also belong the resulting larvæ, pupæ, and moths, and so on.

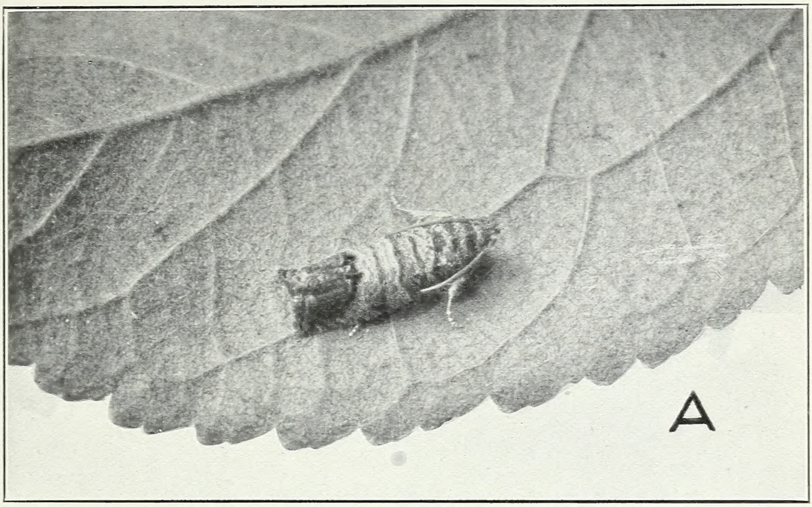
The term "brood" as used in this publication is applied to any stage of the codling moth which may belong to a specific generation or to an unknown generation. For example, the eggs, larvæ, pupæ, and moths which belong to the first generation are called first-brood eggs, larvæ, etc.

The larvæ which pass the winter include all the nontransforming larvæ of the first and second broods, and, in the Grand Valley of Colorado, all of the larvæ of the third brood. The specific generation to which each of these individuals belongs can not be determined unless they have been reared. The term "generation," therefore, can not properly be used to include the various stages of their transformations; they are simply called "wintering" or "spring-brood" larvæ, and the pupæ and moths into which they transform are designated "spring-brood" pupæ and moths.

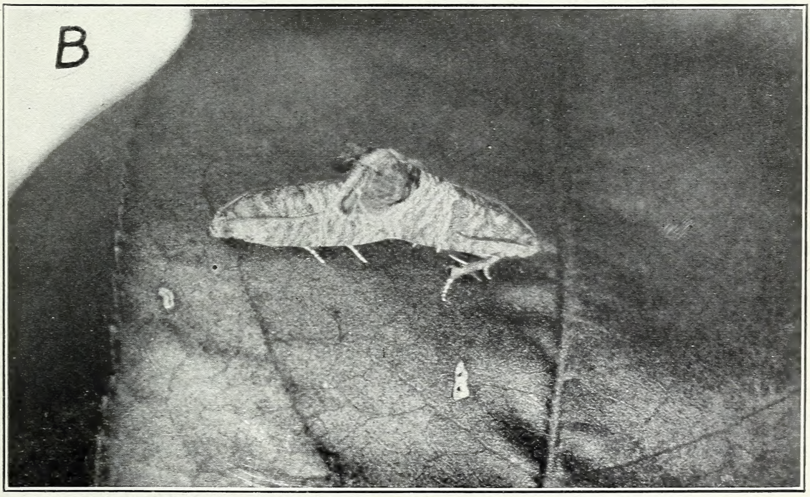
TABLE I.—*Annual meteorological summary, Grand Junction, Colo., 1915.*

Month.	Temperature (° F.).							Precipitation (inches).			Relative humidity.			Sun-shine.		Average cloudiness (scale of 0 to 10).	Wind.				Number of days.										
	Means.			Extremes.																								Max. temp.		Min. temp.	
	Maximum.	Minimum.	Monthly.	Highest.	Date.	Lowest.	Date.	Total.	Greatest in 24 hours.	Total snowfall.	Mean at 6 a. m.	Mean at 6 p. m.	Lowest observed.	Number of hours.	Per cent of possible.		Average velocity (miles per hour).	Prevailing direction.	Maximum velocity (for 5 minutes).	Winds of 40 miles or more per hour.	Clear.	Partly cloudy.	Cloudy.	Precipitation (0.01 inch or more).	Thunderstorms.	Dense fog.	Snowfall (0.01 inch or more melted).	32° or below.	90° or above.	32° or below.	0° or below.
January	31	9	20	41	3	−4	24	0.77	0.28	7.1	93	68	25	193	64	5.5	4.4	W.	21	0	11	8	12	7	0	3	6	19	0	31	4
February	43	2	35	58	11	15	8	0.53	0.29	1.1	86	60	37	166	55	5.5	5.8	W.	39	0	10	7	11	8	0	0	5	0	0	24	0
March	55	32	43	67	26	26	4	0.10	0.10	0.1	63	28	11	256	69	5.1	6.6	W.	48	1	10	14	7	2	0	0	1	0	0	20	0
April	68	45	56	79	28	34	1	1.41	0.47	0	66	34	13	222	56	5.4	8.0	SE.	42	1	8	15	7	11	9	0	0	0	0	0	0
May	70	46	58	88	13	29	2	1.23	0.62	T.	58	30	10	264	60	5.6	8.0	SE.	47	1	9	12	10	10	6	0	0	0	0	2	0
June	82	54	68	93	24	44	4	0.92	0.42	0	46	20	5	377	84	3.0	7.8	E.	45	1	19	7	4	6	5	0	0	0	8	0	0
July	91	64	77	97	11	56	4	0.16	0.13	0	42	20	9	372	82	3.2	8.0	E.	36	0	16	4	1	3	9	0	0	0	19	0	0
August	89	61	75	95	4	54	17	0.51	0.25	0	47	24	8	340	80	2.9	7.9	E.	33	0	19	10	2	7	10	0	0	0	15	0	0
September	78	53	66	90	1	42	14	0.95	0.81	0	56	29	12	275	74	3.8	7.8	SE.	45	1	15	12	3	5	5	0	0	0	1	0	0
October	69	40	54	79	2	33	31	0.01	0.01	0	50	24	12	313	90	2.0	5.9	SE.	29	0	24	5	2	1	0	0	0	0	0	0	0
November	50	28	39	71	5	11	28	0.71	0.27	4.5	66	50	8	230	76	4.9	6.3	E.	43	1	14	6	10	8	1	0	5	0	0	20	0
December	39	22	30	55	14	10	28	1.15	0.38	15.8	85	68	24	164	56	6.3	5.0	SE.	28	0	7	9	15	9	0	0	8	9	0	29	0
Year	64	40	52	97	July 11.	−4	Jan. 24.	8.45	0.81	28.6	63	38	5	3,172	70	4.4	6.8	SE.	48	6	162	119	84	77	45	3	25	28	43	126	4

NOTE.—Precipitation includes rain and melted snow, hail, and sleet. "T." indicates trace of precipitation.



A. ADULT MOTH RESTING ON APPLE LEAF.



B. PAIR OF MOTHS IN COPULA.

THE CODLING MOTH IN THE GRAND VALLEY OF COLORADO.

THE CODLING MOTH IN THE GRAND VALLEY OF COLORADO.

View of experimental orchard.

TABLE II.—*Annual meteorological summary, Grand Junction, Colo., 1916.*

Month.	Temperature (° F.).							Precipitation (inches).			Relative humidity.			Sunshine.		Average cloudiness (scale of 0 to 10).	Wind.			Number of days.											
	Means.			Extremes.																								Max. temp.		Min. temp.	
	Maximum.	Minimum.	Monthly.	Highest.	Date.	Lowest.	Date.	Total.	Greatest in 24 hours.	Total snowfall.	Mean at 6 a. m.	Mean at 6 p. m.	Lowest observed.	Number of hours.	Per cent of possible.		Average velocity (miles per hour).	Prevailing direction.	Maximum velocity (for 5 minutes).	Winds of 40 miles or more per hour.	Clear.	Partly cloudy.	Cloudy.	Precipitation (0.01 inch or more).	Thunderstorms.	Dense fog.	Snowfall (0.01 inch or more melted).	32° or below.	90° or above.	32° or below.	0° or below.
January	32	13	22	50	28	−7	31	1.18	0.23	15.2	92	78	36	130	43	7.5	5.2	NW.	51	1	4	8	19	16	0	1	15	16	0	31	2
February	43	21	32	54	24	−9	1	0.45	0.16	1.5	89	68	36	228	73	4.6	4.6	NW.	34	0	10	12	7	6	0	2	3	4	0	28	2
March	58	34	46	72	19	16	3	0.71	0.32	6.9	63	36	12	301	81	3.9	7.6	NW.	36	0	17	6	8	7	0	0	2	1	0	12	0
April	66	40	53	82	28	27	20	0.20	0.13	0.9	58	27	8	283	71	5.4	7.4	SE.	37	0	9	13	8	4	0	0	1	0	0	7	0
May	73	45	59	88	9	32	15	1.05	1.04	0	43	15	5	359	81	3.8	8.9	NW.	49	1	16	10	5	3	1	1	0	0	0	0	0
June	86	57	72	94	30	43	2	T.	T.	0	30	10	5	418	94	1.7	8.4	NW.	34	0	25	5	0	0	1	0	0	0	11	0	0
July	90	64	77	98	5	57	4	0.76	0.33	0	52	28	8	333	73	4.3	8.0	SE.	37	0	9	17	5	8	11	0	0	0	16	0	0
August	84	61	72	92	1	54	31	2.16	0.75	0	62	32	10	319	75	4.0	7.6	SE.	35	0	14	13	4	8	12	0	0	0	1	0	0
September	79	52	66	88	4	42	28	0.50	0.28	0	54	24	12	318	85	2.6	7.7	SE.	37	0	19	10	1	4	3	0	0	0	0	0	0
October	63	39	51	75	6	29	19	2.12	0.52	0	78	46	23	247	71	3.4	7.1	SE.	38	0	18	7	6	11	4	0	0	0	0	8	0
November	48	23	36	69	5	6	13	0.34	0.19	4.8	72	42	22	254	84	2.6	5.9	SE.	56	1	19	8	3	2	0	0	2	2	0	26	0
December	35	14	25	55	6	0	28	0.27	0.14	5.8	84	63	32	181	62	5.4	5.8	NW.	38	0	9	14	8	8	0	0	7	15	0	30	1
Year	63	39	51	98	July 5.	−9	Feb. 1.	9.74	1.04	35.1	65	39	5	3,370	74	4.1	7.0	SE.	56	3	169	123	74	77	32	4	30	38	28	142	5

NOTE.—Precipitation includes rain and melted snow, hail, and sleet. "T." indicates trace of precipitation.

As mentioned previously and explained later, the larvæ which hatch from the eggs deposited by the second brood of moths do not transform into pupæ and moths the same season as hatched, but pass the winter in the larva stage. Hence there is, in the Grand Valley of Colorado, what might be called a "partial" or "incomplete" third generation. However, these eggs and larvæ are known as third-brood eggs and larvæ.

The "life cycle" of a generation includes the time from the deposition of the egg to the emergence of the moth of the same generation.

The "complete life cycle" extends from the time of the deposition of the egg of one generation to the deposition of the egg of the next generation and, strictly speaking, should include the female sex only.

The seasonal-history studies begin with the wintering or spring-brood larvæ which transform to pupæ of the spring brood and from which issue the moths of the spring brood.

The moths of the spring brood deposit the eggs of the first brood, which, upon hatching, are known as larvæ of the first brood. Some of these remain in the larva stage until the following spring, while the remainder transform successively into the pupæ and moths of the first brood.

The moths of the first brood produce the eggs of the second brood, which, after their incubation period, result in the larvæ of the second brood. Some of these, like some of the first-brood larvæ, are wintering individuals, while the others transform and become successively the pupæ and moths of the second brood.

The moths of the second brood deposit the eggs of the third brood. In the Grand Valley of Colorado all the larvæ of this brood pass the winter, comprising part of the spring brood of pupæ and moths the following season.

Wintering larvæ or larvæ of the spring brood (*spring-brood larvæ*) include: All of the nontransforming larvæ of the first and second broods and all of the larvæ of the third brood.

Pupæ of the spring brood (*spring brood pupæ*) include: All of the pupæ from the spring-brood larvæ.

Moths of the spring brood (*spring-brood moths*) include: All of the moths from the pupæ of the spring brood.

The first generation includes:

1. The eggs of the first brood.
2. The larvæ of the first brood:
    (*a*) Transforming first-brood larvæ;
    (*b*) Wintering first-brood larvæ.
3. The pupæ of the first brood.
4. The moths of the first brood.

The second generation includes:

1. The eggs of the second brood.
2. The larvæ of the second brood:
    - (*a*) Transforming second-brood larvæ;
    - (*b*) Wintering second-brood larvæ.
3. The pupæ of the second brood.
4. The moths of the second brood.

The third generation (*not complete in the Grand Valley*) includes:

1. The eggs of the third brood.
2. The larvæ of the third brood, all of which are wintering individuals.

METHODS AND REARING APPARATUS EMPLOYED IN THE LIFE-HISTORY STUDIES.

The methods used in the study of the biology of the codling moth in the Grand Valley were in most respects like those employed in similar investigations of the bureau at other places.

The rearing apparatus likewise conformed with that previously used, with the exception of an improved cocooning rack, devised by Mr. Van Leeuwen. This device was made of wooden strips 8 inches long, 1¾ inches wide, ¼ inch thick, having two rows of compartments or cells, each cell of which would accommodate one codling moth larva. These cells were covered with a strip of celluloid, through which the transformation of the insect could be observed, and the record of the observations was kept by placing a reference number at the head of each cell in the space provided for that purpose. After the inspection of the insects, the cells were covered by a strip of wood one-eighth inch in thickness, which was held in place by means of wire clamps made from paper clips. Three views of the cocooning rack are shown in Plate III: *a*, the rack with cover removed, showing the cells and larvæ within as well as the reference numbers; *b*, side view, showing cover held in place by wire clamps; *c*, top view.

The cages used in the studies usually consisted of glass battery jars, 6 by 8 inches, covered with cloth tops which are held in place by rubber bands.

The oviposition cages consisted of the regular battery jars, the bottoms of which were covered with a 2-inch layer of slightly moist sand. A fresh twig of apple or pear foliage was placed daily in each cage, as was also a small piece of sponge moistened with a solution of brown sugar.

The incubation cages, in which the eggs were kept, were similar to those used for oviposition purposes. The leaves, on which the eggs had been deposited, were held in a flat position between two pieces of wire screen for a day or more to prevent curling while they dried.

Pupation studies.—The time of pupation of the larvæ was found by a daily examination of the cocooning racks.

Studies of the pupal period.—The pupal period was determined for each individual by noting the time of pupation and emergence of the moth.

Studies of moth emergence.—The records of the emergence of moths were made daily.

Studies of the oviposition.—In order to secure data on the oviposition of the moths, it was necessary to confine the moths issuing on different days in separate cages. The foliage in these cages was removed daily and the number of eggs recorded.

Studies of the length of life of moths.—At the time of changing the foliage in the oviposition cages, all dead moths were removed. The sex was then determined and the length of life computed.

Studies of the incubation period.—The two distinct embryological stages of the eggs previous to hatching were noted, namely, (1) the "red-ring stage," or the first marked indication of the development of the circulatory system, and (2) the so-called "black-spot stage," or the initial appearance of the black head of the developing larva. (See Pl. IV, B.)

Studies of the larval feeding periods.—The feeding studies of the larvæ of the first brood were conducted in two ways: (1) By the stock-jar method and (2) by the bagged-fruit method. The feeding periods of the larvæ of the second and third broods were ascertained according to the stock-jar method only.

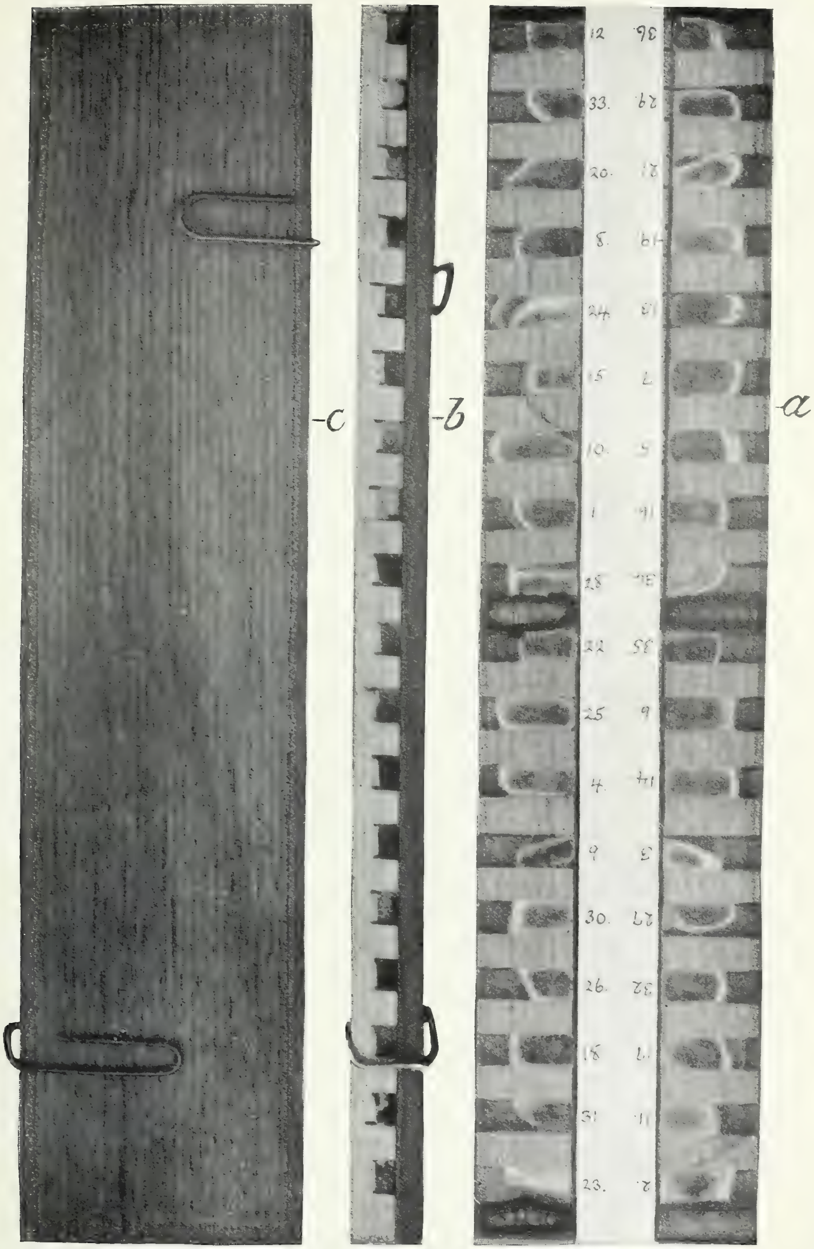
In the stock-jar method, apples free from codling-moth larvæ were placed in a wire basket within a battery jar into which were introduced newly-hatched larvæ. These soon entered the apples and completed their feeding period within the fruit. Cocooning racks were placed in each jar and these were examined daily to ascertain when the larvæ left the fruit, and from these data the length of the feeding period was computed.

The bagged-fruit method consisted in placing newly-hatched larvæ on apples developing on the tree and covering the fruit with finely perforated paper bags. The fruit selected was first carefully examined to insure its freedom from previous infestation. The inclosed fruit was allowed to remain on the tree for a period of two weeks, after which it was removed and kept at the insectary under conditions identical with those described for the stock-jar method.

THE INSECTARY.

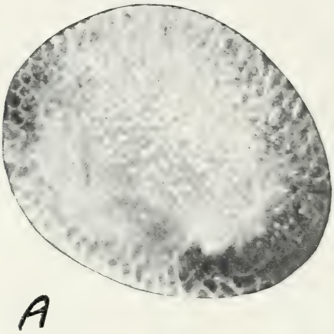
Most of the life-history studies of the codling moth were made at the insectary, a partial interior view of which is shown in Plate V. This was located to the rear of the laboratory and was partially

PLATE III.



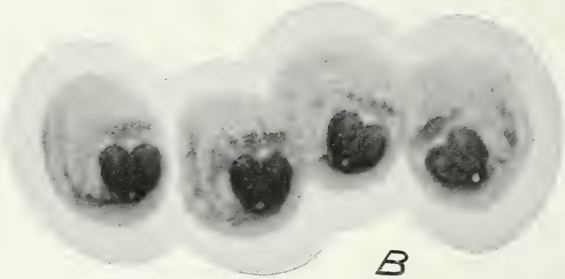
THE CODLING MOTH IN THE GRAND VALLEY OF COLORADO.

Three views of cocooning rack: *a*, With cover removed to show the cocooning cells; *b*, side view; *c*, top view.



A. EGG.

Greatly enlarged.



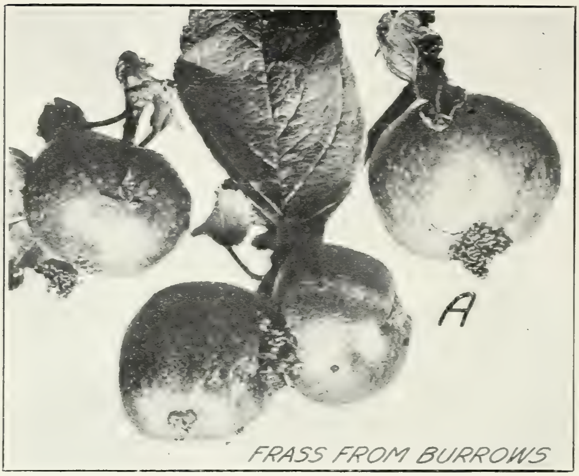
B. EGGS IN ADVANCED BLACK-SPOT STAGE ALMOST READY TO HATCH.

Greatly enlarged.

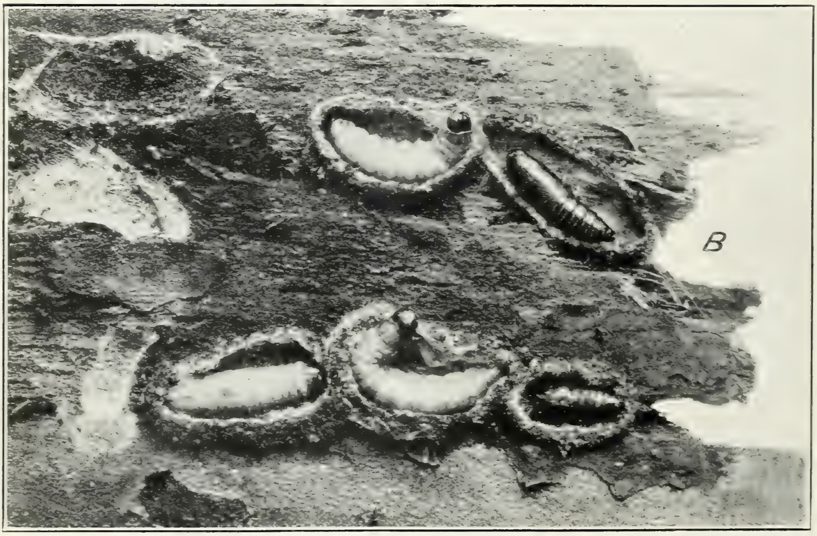
THE CODLING MOTH IN THE GRAND VALLEY OF COLORADO.

THE CODLING MOTH IN THE GRAND VALLEY OF COLORADO.

Interior view of insectary.



A. APPLES INFESTED WITH LARVÆ.



B. LARVÆ AND PUPÆ IN COCOONS.

THE CODLING MOTH IN THE GRAND VALLEY OF COLORADO.

shaded by trees, vines, awnings, and other buildings. As will be noted in the photograph, the insectary was of open-type construction, permitting free circulation of the air; it was 40 feet long and 11 feet wide, with the lowest part of the roof 11 feet in elevation. The temperature conditions within the insectary closely paralleled those in the orchards, as was determined by frequent observations. A thermograph and maximum and minimum thermometers were kept in the insectary for temperature records; and the average daily temperatures used in the various graphs and charts throughout this publication were computed for each day by adding the temperature recorded by this thermograph for each hour of that day and dividing the sum by 24. Other data pertaining to weather conditions were obtained through the courtesy of the local station of the United States Weather Bureau, which was located within a half mile of the insectary.

SEASONAL-HISTORY STUDIES OF 1915.

The seasonal-history studies of the codling moth were commenced in 1915 with the observations of the time of pupation of the spring-brood larvæ.[1] The climate throughout the season was generally normal, except in early May, when subnormal temperatures which fell below the freezing point occurred successively on the mornings of May 1 to 4 inclusive and again on May 7. On the 2d of May the temperature dropped to 22° or 23° F. in many sections of the valley, one exception being the Palisade peach district, which is usually favored with higher minimum temperatures. At the time of the freezes most apples had just dropped their blossoms, except the late-blooming varieties, as Rome Beauty and Jeniton.

As a result of the low temperatures, the apple crop in the Grand Valley, with the exception of that included in the Palisade district and in a few orchards where oil heaters were employed, was practically destroyed. Here and there were to be found a few pears, the blossoms of which seemingly were not so readily destroyed by the freezes as were those of the apple. The general shortage of the apple crop, however, did not in any way interfere with the life-history studies, since sufficient fruit was at hand for feeding and other purposes.

In referring to the tables the reader should bear in mind that each table is a unit in itself. Successive tables are not necessarily continuations of the life history of all of the individuals given in the previous table. For example, it will be noted that Table III is the record of the time of pupation of 320 wintering larvæ and that Table IV includes observations on the length of the pupal stage of only 233 of these individuals. Differences of this character may be due to natural or artificial causes, such as death, accidental injury, parasites, the removal of specimens for other purposes, etc.

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[1] These larvæ were collected from banded apple trees in the fall of 1914 by Mr. R. J. Fiske, of the Bureau of Entomology.

WINTERING LARVÆ.

As previously stated (p. 6), the wintering larvæ consist of all of the nontransforming larvæ of the first and second broods and all of the larvæ of the third brood. (See Plate VI, B.)

The winter cocoon.—The winter cocoon is a small, well-built structure, having heavy silk walls in which are frequently interwoven small particles of bark. When compared with the more hastily constructed summer cocoon, it will be noted that the winter cocoon is of heavier construction and thus affords the larva protection against the low temperatures of the winter season. The cocoon is generally more or less oval in form, but varies to conform with the space in which it is built. The winter cocoon is usually found beneath the bark on the trunk of the tree, well concealed from birds and insect enemies, in the crotches of the larger limbs, or in decayed or partially decayed tree cavities, etc. Not infrequently, in the Grand Valley, a mass of 10 to 20 cocoons, side by side or partially on top of one another, may be found on the tree in places particularly favorable for hibernation. The cocoons are occasionally to be found around the base of the tree just below the surface soil or within cracks in the soil. Again, a considerable number of winter cocoons are constructed in various cracks and crevices within packing houses and storage cellars where the harvested fruit has been kept.

Remodeling of the cocoon.—The wintering larva begins activity during the first warm days of spring; it then remodels its cocoon by attaching thereto a slender silken exit tube which provides for the safe issuance of the moth. This tube is usually a fraction of an inch in length, although tubes have been found that were 2 or more inches long, depending upon the location of the cocoon. Upon the completion of the exit tube a lightly constructed silken partition, which serves to separate the tube from the cocoon proper, is frequently built at its base.

Emergence of the moth.—Shortly before the time the moth emerges, the pupa punctures this silken partition and, by means of its retrose spines, wriggles its way to the end of the exit tube. The moth then ruptures the pupal skin, crawls into clear space, spreads and dries its wings, and in due course of time takes flight. Were it not for the exit tube, many moths would be unable to free themselves from the place in which the larvæ have cocooned.

PUPÆ OF THE SPRING BROOD.

Time of pupation.—Observations of the time of pupation of the wintering larvæ were made daily by examination of the larvæ within the cocooning racks. The tabulated results showing the time of pupation of 320 larvæ are given in Table III and illustrated in figure 1.

It will be noted that the earliest pupation occurred April 14, when two larvæ transformed, and that the last of the wintering larvæ pupated June 8 or approximately 8 weeks later. On April 26 there was a marked increase in the rate of pupation and a still greater increase two days later, owing to higher temperatures, as shown in figure 1. Following this activity the temperatures became abnormally low, reaching in the insectary a minimum of 27° F. on May 2, on this date only one larva pupating. This freeze contributed largely to the destruction of practically the entire fruit crop of the Grand Valley west of the Palisade district. Freezing temperatures recurred on the mornings of May 3, 4, and 7, but on the latter date the temperature reached a maximum of 70° F., and, as a result, 18 larvæ pupated. Pupation thereafter continued quite regularly (except on May 10) and reached its maximum on May 12. During the period of one week, May 7 to 13, inclusive, approximately 40 per cent of the wintering larvæ pupated. Following this crest of activity the rate of pupation gradually diminished in the normal way.

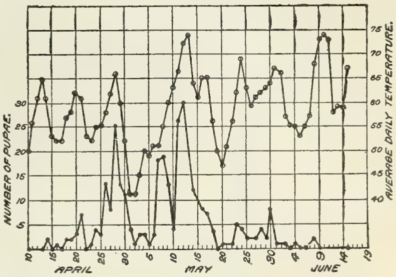

FIG. 1.—Time of pupation of spring-brood pupæ of the codling moth, Grand Junction, Colo., 1915.

TABLE III.—*Time of pupation of wintering larvæ of the codling moth, Grand Junction, Colo., 1915.*

Date of pupation.	Number of pupæ.	Date of pupation.	Number of pupæ.	Date of pupation.	Number of pupæ.	Date of pupation.	Number of pupæ.	Date of pupation.	Number of pupæ.
Apr. 14	2	Apr. 26	13	May 8	19	May 20	1	June 1	1
15	0	27	8	9	13	21	1	2	1
16	1	28	25	10	4	22	1	3	0
17	0	29	13	11	26	23	5	4	1
18	2	30	11	12	30	24	4	5	0
19	2	May 1	4	13	20	25	2	6	0
20	3	2	1	14	12	26	2	7	1
21	7	3	3	15	10	27	2	8	2
22	0	4	3	16	8	28	4		
23	1	5	1	17	7	29	2	Total...	320
24	4	6	3	18	4	30	8		
25	3	7	18	19	0	31	1		

Length of the pupal stage.—In Table IV will be found the length of the pupal stage of 233 pupæ of the spring brood. Reference to this table will show that the first pupation occurred April 14 and the last June 7. The pupal period of the individuals that pupated early in the season was naturally longer, owing to the lower average temperatures, than was the pupal period of those insects that transformed later in the spring. The average length of the pupal stage was 27.58 days, the maximum 34 days, and the minimum 15 days.

TABLE IV.—*Length of the pupal stage of pupæ of the spring brood of the codling moth, Grand Junction, Colo., 1915.*

Date of pupation.	Number of individuals.	Length of the pupal stage in specified days.														
		15	21	22	23	24	25	26	27	28	29	30	31	32	33	34
Apr. 14	1	....	....	....	....	....	....	....	....	....	....	....	....	1	....	....
16	1	....	....	....	....	....	....	....	....	....	....	....	....	1	....	....
18	2	....	....	....	....	....	....	....	....	....	....	1	1	....	....	....
19	2	....	....	....	....	....	....	....	....	....	1	....	....	....	....	1
20	2	....	....	....	....	....	....	....	....	....	....	....	....	....	....	2
21	7	....	....	....	....	....	....	....	....	....	....	....	....	1	5	1
23	1	....	....	....	....	....	....	....	....	....	....	....	1	....	....	....
24	3										1	2	....	....	....	....
25	2	....	....	....	....	....	....	....	....	....	....	1	....	1	....	....
26	10	....	....	....	....	....	....	....	....	....	6	1	3	....	....	....
27	7	....	....	....	....	....	....	....	....	....	....	3	3	1	....	....
28	18	....	....	....	....	....	....	....	....	....	2	6	4	6	....	....
29	10	....	....	....	....	....	....	....	....	....	....	2	6	2	....	....
30	8	....	....	....	....	....	....	....	....	1	....	4	3	....	....	....
May 1	3	....	....	....	....	....	....	....	....	....	2	1				
3	3	....	....	....	....	....	....	....	2	....	1	....	....	....	....	....
4	3	....	....	....	....	....	....	....	1	2	....	....	....	....	....	....
5	1	....	....	....	....	....	....	1	....	....	....	....	....	....	....	....
6	3	....	....	....	....	1	2	....	....	....	....	....	....	....	....	....
7	15	....	....	....	....	4	11	....	....	....	....	....	....	....	....	....
8	15	....	....	1	1	10	....	2	....	1	....	....	....	....	....	....
9	7	....	....	....	3	1	3	....	....	....	....	....	....	....	....	....
10	2	....	....	....	....	1	....	1	....	....	....	....	....	....	....	....
11	21	....	1	....	1	....	1	....	5	8	4	....	1	....	....	....
12	20	....	....	....	....	....	....	2	6	10	2	....	....	....	....	....
13	17	....	....	....	....	....	....	....	3	12	2	....	....	....	....	....
14	10	....	....	....	....	....	....	....	7	1	1	....	1	....	....	....
15	6	....	....	....	....	....	....	....	3	3	....	....	....	....	....	....
16	3	....	....	....	....	....	....	....	2	....	1	....	....	....	....	....
17	6	....	....	....	....	1	1	1	....	1	2	....	....	....	....	....
18	4	....	....	....	....	....	1	....	3	....	....	....	....	....	....	....
21	1	....	....	....	....	1	....	....	....	....	....	....	....	....	....	....
22	1	....	....	....	....	1	....	....	....	....	....	....	....	....	....	....
23	3	....	....	1	1	1	....	....	....	....	....	....	....	....	....	....
24	2	....	....	1	1	....	....	....	....	....	....	....	....	....	....	....
25	1	....	....	....	1	....	....	....	....	....	....	....	....	....	....	....
26	1	....	....	....	....	1	....	....	....	....	....	....	....	....	....	....
27	2	....	....	1	1	....	....	....	....	....	....	....	....	....	....	....
28	2	....	....	2	....	....	....	....	....	....	....	....	....	....	....	....
30	6	....	6	....	....	....	....	....	....	....	....	....	....	....	....	....
June 7	1	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....
	233	1	7	6	9	22	19	7	32	39	25	21	23	13	5	4

	Days.
Average length of pupal stage	27.58
Maximum length of pupal stage	34
Minimum length of pupal stage	15

MOTHS OF THE SPRING BROOD.

Time of emergence.—The tabulated data of the emergence of 1,539 moths of the spring brood are given in Table V. It will be noted in this table that the first moths issued May 12, while the last moth of this brood did not emerge until June 29 or nearly seven weeks later. The emergence is largely dependent upon temperature and atmospheric conditions and hence the number of moths issuing daily fluctuates more or less in accordance with the climatic factors. The number of moths appearing daily gradually increased (with one exception) up to May 17, as shown diagrammatically in figure 2, and probably would have continued growing larger had it not been for the retarding influence of the weather, which began May 18 and continued to May 21, inclusive. The temperature dropped considerably on May 18 and was accompanied by 0.12 inch of precipitation.

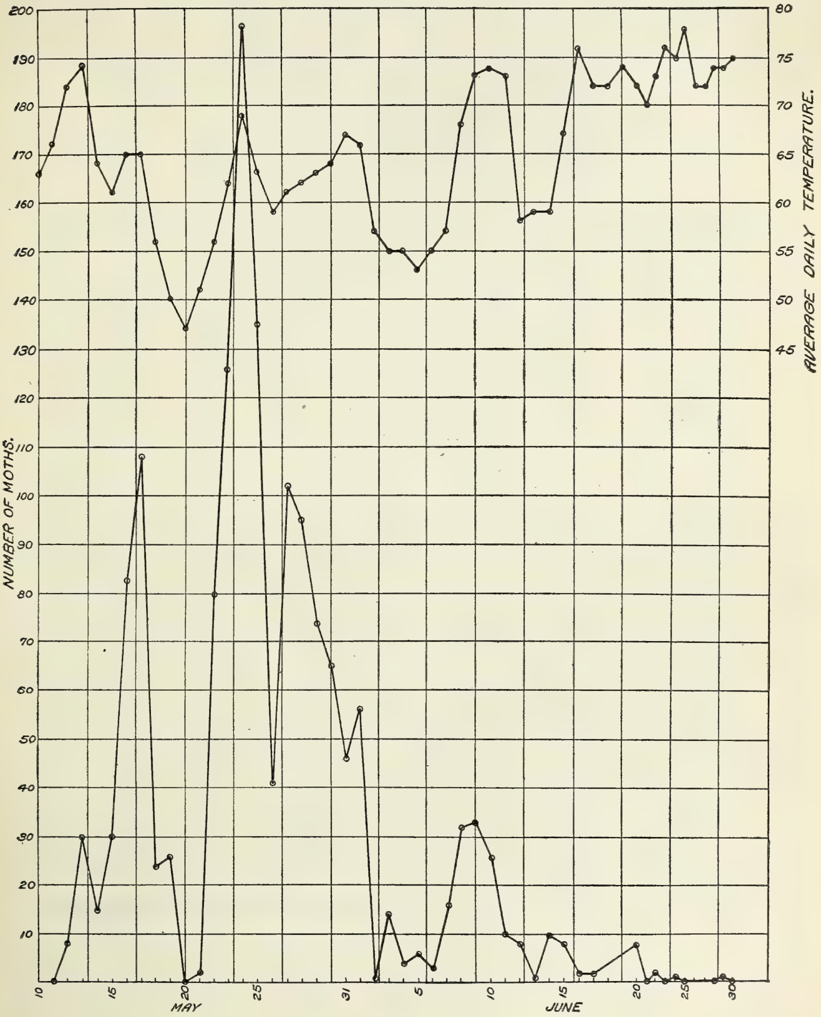

FIG. 2.—Time of emergence of moths of the spring brood of the codling moth, Grand Junction, Colo., 1915.

On the following day, May 19, the temperature dropped somewhat lower and heavy rains (0.44 inch) occurred in the afternoon and evening. The next day, May 20, was colder than the two preceding days, the maximum temperature being 58° F. and the minimum 44° F. In addition to the low temperature, it rained practically the entire day, with a total of 0.29 inch of precipitation. The development and activity of the codling moth were almost completely arrested, with the result that no moths issued and no eggs were deposited. With normal temperature conditions on May 18, 19, and 20, the emergence of moths would doubtless have been large. The weather turned increasingly warmer May 22, 23, and 24, and on the latter date the maximum number of moths (196) issued. Thereafter the emergence gradually decreased, the rate conforming closely to the variations of the temperature until all of the moths had issued.

TABLE V.—*Time of emergence of codling moths of the spring brood, Grand Junction, Colo., 1915.*

Date of emergence.	Number of moths.	Date of emergence.	Number of moths.	Date of emergence.	Number of moths.	Date of emergence.	Number of moths.	Date of emergence.	Number of moths.
May 12	8	May 23	126	June 2	1	June 12	8	June 22	2
13	30	24	196	3	14	13	1	23	0
14	15	25	135	4	4	14	10	24	1
15	30	26	41	5	6	15	8	25	0
16	83	27	102	6	3	16	2	26	0
17	108	28	95	7	15	17	2	27	0
18	24	29	74	8	32	18	4	28	0
19	26	30	65	9	33	19	6	29	1
20	0	31	46	10	26	20	8		
21	2	June 1	56	11	10	21	0	Total...	1,539
22	80								

Oviposition by moths of the spring brood.—In Table VI are recorded the observations of the oviposition of 1,140 female moths confined with 1,007 male moths in 92 cages. In this connection it is of interest to note the variations in the time of oviposition by the moths in the several cages. Thus, moths emerging May 12 and confined in cage 1 did not deposit eggs until May 22, whereas the moths in cage 2, although issuing a day later, commenced oviposition May 15. A more detailed study of the table will show numerous variations of the oviposition habits of the moths. A summary of the data is as follows: The number of days before oviposition averaged 6.19, the maximum was 19, and the minimum 2; the number of days for the period of oviposition averaged 13.82, maximum 33, minimum 1; the average number of days from the date of emergence to the date of last oviposition was 19.14, maximum 37, minimum 5.

Number of eggs per female moth.—It was found in the oviposition studies of the moths of the spring brood that the average number of eggs deposited was 12.59 per female moth. This number was obtained by dividing the total number of eggs deposited by the total number of female moths caged, as shown in Table VI.

TABLE VI.—*Oviposition of codling moths of the spring brood in rearing cages, Grand Junction, Colo., 1915.*

Cage No.	Number of moths.	Sex.		Date of—			Total number of eggs deposited.	Number of days—		
		Male.	Female.	Emergence of moths.	First oviposition.	Last oviposition.		Before oviposition.	Of oviposition period.	From date of emergence to last oviposition.
1	29	15	14	May 12	May 22	June 1	82	10	11	20
2	20	6	14	May 13	May 15	June 9	230	2	26	27
3	24	11	13	...do.....	May 24	June 3	162	11	11	21
4	28	12	16	May 14	May 17	May 31	207	3	15	17
5	25	12	13	May 15	May 18	June 15	231	3	29	31
6	25	9	16	May 16	...do.....	June 11	346	2	25	26
7	25	11	14	...do.....	May 21	June 22	508	5	33	37
8	24	12	12	...do.....	May 22	June 7	70	6	17	22
9	19	6	13	...do.....	May 23	June 4	94	7	13	19
10	23	7	16	...do.....	May 28	June 2	2	12	6	17
11	34	14	20	May 17	May 22	June 14	222	5	24	28
12	23	10	13	...do.....	May 24	June 1	115	7	9	15
13	22	15	7	...do.....	...do.....	June 11	162	7	19	25
14	27	16	11	...do.....	...do.....	June 15	271	7	23	29
15	25	16	9	May 18	May 25	June 13	151	7	20	26
16	28	19	9	May 19	...do.....	June 17	80	6	24	29
17	8	5	3	May 21	June 9	June 10	83	19	2	20
18	22	7	15	May 22	May 24	June 14	299	2	22	23
19	25	13	12	...do.....	May 25	June 11	204	3	18	20
20	27	15	12	...do.....	...do.....	...do.....	77	3	18	20
21	16	5	11	...do.....	May 29	June 9	130	7	12	18
22	21	10	11	May 23	May 25	June 15	74	2	22	23
23	25	14	11	...do.....	...do.....	June 17	149	2	24	25
24	23	8	15	...do.....	May 27	June 8	85	4	13	16
25	21	7	14	...do.....	May 31	June 17	132	8	18	25
26	12	7	5	...do.....	June 9	June 23	5	17	15	31
27	24	15	9	May 24	May 27	June 19	216	3	24	26
28	28	13	15	...do.....	May 31	June 20	176	7	21	27
29	23	12	11	...do.....	June 1	June 8	78	8	8	15
30	24	10	14	...do.....	...do.....	June 11	88	8	11	18
31	20	8	12	...do.....	...do.....	June 19	98	8	19	26
32	26	10	16	...do.....	...do.....	June 25	28	8	25	32
33	26	15	11	...do.....	June 3	June 23	451	10	21	30
34	23	8	15	...do.....	June 6	June 19	226	13	14	26
35	24	15	9	May 25	May 28	June 18	200	3	22	24
36	24	10	14	...do.....	May 30	June 17	284	5	19	23
37	21	9	12	...do.....	June 1	June 19	53	7	19	25
38	23	13	10	...do.....	June 9	June 15	21	15	7	21
39	22	9	13	May 26	May 31	June 19	413	5	20	24
40	20	9	11	...do.....	...do.....	...do.....	419	5	20	24
41	30	12	18	May 27	June 1	...do.....	100	5	19	23
42	25	13	12	...do.....	...do.....	June 6	52	5	6	10
43	21	9	12	...do.....	...do.....	June 18	244	5	18	22
44	22	12	10	...do.....	May 31	June 16	204	4	17	20
45	24	14	10	May 28	June 1	...do.....	189	4	16	19
46	24	10	14	...do.....	...do.....	...do.....	243	4	16	19
47	22	7	15	...do.....	...do.....	June 19	333	4	19	22
48	22	7	15	...do.....	...do.....	June 26	235	4	26	29
49	25	8	17	May 29	June 2	June 18	323	4	17	20
50	31	14	17	...do.....	...do.....	June 28	457	4	27	30
51	21	8	13	...do.....	June 4	June 16	138	6	13	18
52	19	11	8	...do.....	June 7	...do.....	92	9	10	18
53	23	15	8	...do.....	June 10	June 11	39	12	2	13
54	20	9	11	May 30	June 4	June 19	221	5	16	20
55	26	8	18	...do.....	...do.....	June 22	296	5	19	23
56	25	14	11	...do.....	June 7	June 17	157	8	11	18
57	23	14	9	...do.....	June 9	June 22	126	10	14	23
58	23	15	8	May 31	June 7	June 7	5	7	1	7
59	20	11	9	...do.....	...do.....	June 17	117	7	11	17
60	26	10	16	...do.....	June 9	June 14	67	9	6	14
61	21	10	11	...do.....	...do.....	...do.....	51	9	6	14
62	24	14	10	June 1	June 7	June 16	111	6	10	15
63	22	13	9	...do.....	June 10	June 19	94	9	10	18
64	27	12	15	...do.....	...do.....	...do.....	113	9	10	18
65	11	3	8	June 2	June 11	June 12	54	9	2	10
66	23	11	12	June 3	June 9	June 16	183	6	8	13
67	11	7	4	June 4	June 10	June 11	49	6	2	7
68	6	4	2	June 5	June 11	June 22	82	6	12	17
69	19	9	10	June 6	...do.....	June 21	28	5	11	15

TABLE VI.—*Oviposition of codling moths of the spring brood in rearing cages, Grand Junction, Colo., 1915*—Continued.

Cage No.	Number of moths.	Sex.		Date of—			Total number of eggs deposited.	Number of days—		
		Male.	Female.	Emergence of moths.	First oviposition.	Last oviposition.		Before oviposition.	Of oviposition period.	From date of emergence to last oviposition.
70	23	10	13	June 7	June 11	June 20	251	4	10	13
71	25	15	10	...do.....	June 16	June 16	3	9	1	9
72	27	15	12	June 8	June 11	June 27	250	3	7	19
73	22	13	9	...do.....	June 18	June 21	10	10	4	13
74	22	7	15	...do.....	June 21	June 25	7	13	5	17
75	31	18	13	June 9	June 16	June 26	238	7	11	17
76	29	12	17	...do.....	...do.....	June 27	52	7	12	18
77	33	13	20	June 10	June 12	June 23	211	2	12	13
78	31	21	10	...do.....	...do.....	June 26	100	2	15	16
79	31	18	13	...do.....	June 15	June 25	367	5	11	15
80	38	16	22	June 11	June 16	...do.....	134	5	10	14
81	29	14	15	June 12	...do.....	June 23	275	4	8	11
82	9	1	8	June 13	June 19	June 21	7	6	3	8
83	20	10	10	June 14	....	....	[1] 1	....	....	......
84	30	13	17	June 15	June 18	June 29	54	3	12	14
85	32	11	21	June 16	June 19	June 26	129	3	8	10
86	30	13	17	June 17	...do.....	July 3	293	2	15	16
87	25	7	18	June 18	June 22	June 30	92	4	9	12
88	25	10	15	...do.....	June 23	July 1	202	5	9	13
89	24	10	14	June 19	June 24	July 4	152	5	11	15
90	25	11	14	June 20	June 22	July 1	182	2	10	11
91	12	4	8	June 21	....	....	0	....	....	......
92	9	3	6	June 22	June 27	June 27	24	5	1	5
Average							....	6.19	13.82	19.14
Maximum							....	19	33	37
Minimum							....	2	1	5

[1] Deposited on side of cage.

Number of male moths	1,007
Number of female moths	1,140
Total number of moths	2,147
Total number of eggs	14,359
Average number of eggs per female moth	12.59

Length of life of moths.—The dead moths in the oviposition cages were removed each day; their sex was then determined and the length of their life computed. The results of these observations are given in Table VII, in which it will be found that the average length of life of 1,283 male moths was 14.59 days and of 1,462 female moths 15.86 days; the maximum length of life of the male moths was 36 days, of the female moths 39 days; the minimum length of life of the male moths was 1 day, of the female moths 1 day.

TABLE VII.—*Length of life of male and female codling moths of the spring brood in captivity: Summary of records of 2,745 individual moths, Grand Junction, Colo., 1915.*

Male.		Female.		Male.		Female.		Male.		Female.	
Length of life.	Number of moths.	Length of life.	Number of moths.	Length of life.	Number of moths.	Length of life.	Number of moths.	Length of life.	Number of moths.	Length of life.	Number of moths.
Days.		*Days.*		*Days.*		*Days.*		*Days.*		*Days.*	
1	9	1	5	15	61	15	95	29	8	29	15
2	9	2	3	16	58	16	99	30	11	30	6
3	4	3	5	17	58	17	88	31	4	31	4
4	14	4	11	18	50	18	73	32	6	32	5
5	29	5	12	19	41	19	72	33	5	33	10
6	46	6	18	20	65	20	91	34	3	34	2
7	63	7	41	21	43	21	69	35	2	35	3
8	79	8	39	22	38	22	36	36	1	36	0
9	49	9	72	23	26	23	37	37	0	37	0
10	77	10	77	24	27	24	33	38	0	38	1
11	65	11	79	25	21	25	28	39	0	39	1
12	71	12	88	26	25	26	24	Total.	1,283	Total.	1,462
13	99	13	97	27	10	27	14				
14	79	14	98	28	17	28	11				

Average length of life of male moths, 14.59 days; female moths, 15.86 days.
Maximum length of life, male moths, 36 days; female moths, 39 days.
Minimum length of life of male moths, 1 day; female moths, 1 day.

THE FIRST GENERATION.

EGGS OF THE FIRST BROOD.

Time of egg deposition.—The first eggs of this brood were deposited on May 13 in a cage in which were confined some of the earliest moths of the spring brood, emerging on different dates. The deposition of the eggs, as shown in Table VIII, continued daily up to and including July 8, with the exception of May 19 and 20, on which days no eggs were laid owing to the unfavorable weather conditions previously mentioned (see p. 13). The greatest number of eggs deposited on any one day was 1,379, as will be noted in the

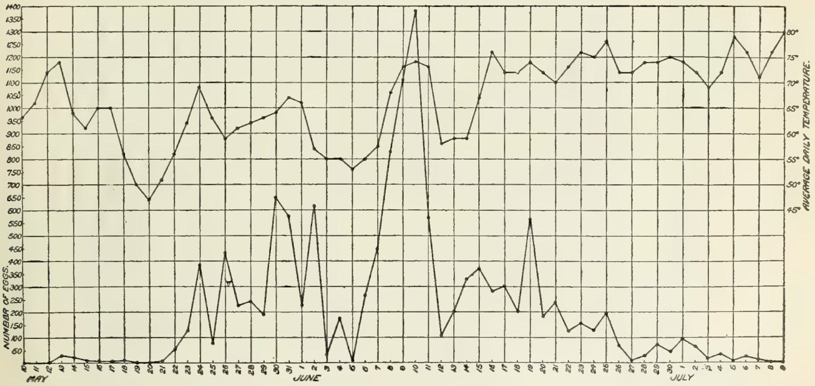

FIG. 3.—Time of deposition of eggs of the first brood of the codling moth, Grand Junction, Colo., 1915.

graph, figure 3. By further reference to this figure it will be seen that the average daily temperatures from June 3 to June 7 were relatively low and that during this period the moths did not deposit very freely. With the rise in temperature from June 7 to 10, the moths were much more active and deposited 828 eggs on June 8, 1,106 eggs on June 9, and the maximum number of eggs, 1,379, on June 10. The average temperature was also high on June 11, but the deposition of eggs was notably less than on the preceding days. Following the crest of egg deposition, the number daily deposited gradually diminished, except on June 19, when 564 eggs were laid.

TABLE VIII.—*Time of deposition, length of incubation, and time of hatching of eggs of the first brood of the codling moth, Grand Junction, Colo., 1915.*

Observation.	Number of eggs.	Date—				Appearance of—		Incubation period.
		Deposited.	Red ring.	Black spot.	Hatched.	Red ring.	Black spot.	
						Days.	*Days.*	*Days.*
1	15	May 13	May 16	May 25	May 27	3	12	14
2	10	...do			May 28			15
3	2	May 14	May 16	May 27	...do	2	13	14
4	20	...do			May 29			15
5	5	May 15	May 17	May 28	...do	2	13	14
6	1	...do			May 30			15
7	4	May 16	May 22	May 29	...do	6	13	14
8	2	...do			May 31			15
9	1	May 17	May 23	May 30	...do	6	13	14
10	5	...do			June 1			15
11	8	May 18	May 27	May 31	...do	9	13	14
12	2	...do			June 2			15
13	5	May 21	May 27	May 31	June 1	6	10	11
14	39	May 22	May 28	...do	June 2	6	9	11
15	12	...do			June 3			12
16	1	...do			June 4			13
17	1	...do			June 5			14
18	45	May 23	May 28	June 1	June 2	5	9	10
19	22	...do			June 3			11
20	34	...do			June 4			12
21	14	...do			June 5			13
22	3	...do			June 6			14
23	7	...do			June 7			15
24	20	May 24	May 29	June 1	June 4	5	8	11
25	136	...do			June 5			12
26	140	...do			June 6			13
27	65	...do			June 7			14
28	19	May 25	May 29	June 4	...do	4	10	13
29	42	...do			June 8			14
30	8	...do			June 9			15
31	284	May 26	May 30	June 4	June 8	4	9	13
32	90	...do			June 9			14
33	2	May 27	May 31	June 7	June 8	4	11	12
34	187	...do			June 9			13
35	157	May 28	May 31	June 7	...do	3	10	12
36	41	...do			June 10			13
37	5	...do			June 11			14
38	120	May 29	June 1	June 8	June 10	3	10	12
39	51	...do			June 11			13
40	162	May 30	June 3	June 9	June 10	4	10	11
41	299	...do			June 11			12
42	19	...do			June 12			13
43	367	May 31	June 3	June 10	June 11	3	10	11
44	57	...do			June 12			12
45	11	...do			June 13			13
46	7	June 1	June 4	June 10	June 12	3	9	11
47	161	...do			June 13			12
48	2	...do			June 14			13
49	324	June 2	June 8	June 11	June 13	6	9	11
50	43	...do			June 14			12
51	30	...do			June 15			13
52	6	June 3		June 11	June 14		8	11
53	29	...do			June 15			12

Table VIII.—*Time of deposition, length of incubation, and time of hatching of eggs of the first brood of the codling moth, Grand Junction, Colo., 1915*—Con.

Observation.	Number of eggs.	Date—				Appearance of—		Incubation period.
		Deposited.	Red ring.	Black spot.	Hatched.	Red ring.	Black spot.	
						Days.	*Days.*	*Days.*
54	46	June 4	June 9	June 11	June 14	5	7	10
55	81	do			June 15	3		11
56	4	June 5		June 13	June 15		8	10
57	1	do			June 16			11
58	1	do			June 17			12
59	163	June 6	June 10	June 12	June 15	4	6	9
60	55	do			June 16			10
61	49	June 7	June 10	June 12	June 15	3	5	8
62	284	do			June 15			9
63	215	June 8	June 10	June 14	June 17	2	6	9
64	191	do			June 18			10
65	619	June 9	June 11	June 16	June 17	2	7	8
66	55	June 10	June 12	do	June 17	2	6	7
67	690	do			June 18	2	6	8
68	69	do			June 19			9
69	233	June 11	June 15	June 18	do	4	7	8
70	85	do			June 20			9
71	76	June 12	June 16	June 18	do	4	6	8
72	12	do			June 21			9
73	102	June 13	June 16	June 19	June 20	3	6	7
74	69	do			June 21			8
75	241	June 14	June 17	June 19	do	3	5	7
76	56	do			June 22			8
77	237	June 15	June 17	June 20	do	2	5	7
78	11	do			June 23			8
79	245	June 16	June 18	June 21	do	2	5	7
80	20	do			June 24			8
81	248	June 17	June 19	June 22	June 23	2	5	6
82	12	do			June 24			7
83	141	June 18	June 21	June 24	June 25	3	6	7
84	49	do			June 25			8
85	502	June 19	June 21	June 24	do	2	5	7
86	149	June 20	June 22	June 25	do	2	5	6
87	25	do			June 27			7
88	198	June 21	June 22	June 28	June 28	1	5	7
89	31	do			June 29			8
90	117	June 22	June 23	June 27	June 28	1	5	6
91	5	do			June 29			7
92	145	June 23	June 24	June 28	June 30	1	5	7
93	3	do			July 1			8
94	13	June 24	June 25	June 29	June 30	1	5	6
95	111	do			July 1			7
96	191	June 25	June 26	June 30	July 2	1	5	7
97	2	do			July 3			8
98	65	June 26	June 28	July 1	do	2	5	7
99	4	do			July 4			8
100	11	June 27	June 29	July 2	do	2	5	7
101	27	June 28	June 30	July 3	do	2	5	6
102	1	do			July 5			7
103	74	June 29	July 1	July 3	do	2	4	6
104	35	June 30	July 2	July 4	July 6	2	4	6
105	7	do			July 7			7
106	94	July 1	July 2	July 6	July 8	1	5	7
107	63	July 2	July 4	July 7	July 9	2	5	7
108	1	do			July 10			8
109	16	July 3	July 6	July 8	July 10	3	5	7
110	33	July 4	do	July 10	July 11	2	6	7
111	1	do			July 12			8
112	[1] 7	July 5	do	July 11		1	6	
113	24	July 6	July 8	July 12	July 13	2	6	7
114	[1] 11	July 7	do			1		
115	[1] 1	July 8						
	Ave.					2.70	6.62	9.14
	Max.					9	13	15
	Min.					1	4	6

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[1] Eggs not included in averages due to failure to develop fully.

Length of incubation.—As will be noted in Table VIII, the earliest eggs required an incubation period about twice as long as those deposited later. This is accounted for by the lower temperatures to which the earlier eggs were subjected. The incubation period gradually decreased as the daily temperatures became higher with the advance of the season. The average number of days from the date of deposition to the time of the appearance of the red ring was 2.70, maximum 9 days, minimum 1 day; the average number of days from the date of deposition to the black-spot stage was 6.62, maximum 13 days, minimum 4 days; the average incubation period was 9.14 days, maximum 15 days, minimum 6 days.

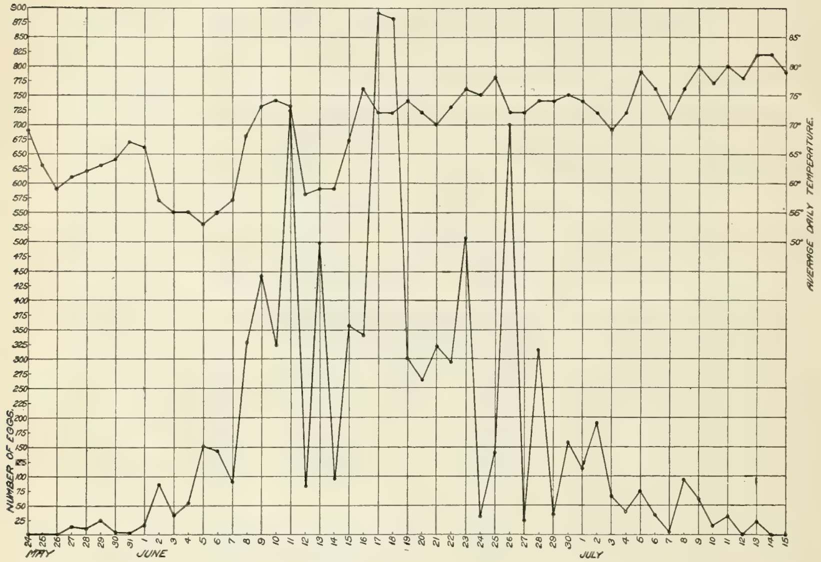


FIG. 4.—Time of hatching of eggs of the first brood of the codling moth, Grand Junction, Colo., 1915.

LARVÆ OF THE FIRST BROOD.

Time of hatching.—Larvæ of the first brood commenced to hatch on May 27 and continued to hatch until July 13, as given in the complete hatching data in Table VIII. The eggs were hatching in maximum numbers on June 17, just one week after the time when the greatest number of eggs was deposited. The interval from the date of the appearance of the first larva to the time of hatching of the larvæ in maximum numbers was 21 days. This interval would probably have been reduced somewhat had the weather been warmer on June 12, 13, and 14. The time of hatching of the eggs of the first brood is presented graphically in figure 4.

Length of the feeding period, stock-jar method.—The length of the feeding period of 758 larvæ of the first brood (both transforming and nontransforming) according to the stock-jar method (see p. 8) is given in Table IX. As will be observed, the length of the feeding period averaged 21.64 days, maximum 35 days, minimum 12 days.

Length of the feeding period, bagged-fruit method.—In Table X will be found the results of the observations of the feeding period of 242 larvæ of the first brood (both transforming and nontransforming) by means of the bagged-fruit method (see p. 8). The average period of feeding was 22.77 days, maximum 35 days, minimum 15 days.

TABLE IX.—*Length of feeding period of larvæ of the first brood of the codling moth, stock-jar method, Grand Junction, Colo., 1915.*

Date of entering fruit.	Number of individuals.	Length of feeding period in specified days.																							
		12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
May 27	1																1								
29	2												2												
30	1													1											
June 5	5										1	1	3												
6	16								1	4	6	1	1	1	2										
7	3									2										1					
8	4								2		2														
9	9							1	3	4			1												
10	19						1	2	3	1	6	4	1						1						
11	39						1		5	6	7	7	2	3	4	2	1			1					
12	6							1	1		1	2					1								
13	9							1	2	1	2		1	1	1										
14	27					1	1	5	2	4	2	3	4	1	2	2									
15	59		1	1	1	5	11	5	3	6	11	3	4	3	1	1	1			1			1		
16	41					2	1	4	2	3	4	6	5	2	2	4		4	1			1			
17	52				1	1	1	8	9	5	6	4		7	2	6	1					1			
18	68				1	2	1	7	7	7	9	10	3	9	2	2	5		2			1			
19	50					1			8	6	9	9	6	3		4	1			3					
20	25						2	1		3	4	2	5	2	2		1	1	1			1			
21	29							1	4	5	5			5		2	5		1						1
22	18						1	2		4	1	1	1	1	2			2	1		1			1	
23	23							2	3	3		4	5	2	2		1	1							
24	24							2	4	1		2	5	2		1	2	2		2		1			
25	13						2	2	2		2		2		1		1							1	
26	24						1	3	5			5		4	2		2		2						
27	24						2		1	5	4		4		1	1	1		2		2				1
28	34					1	2	1	4		2	5	4	4		5		1			2		3		
29	15				2			5	3		3			1					1						
30	10						1	2	2	2	2					1									
July 1	12					1	4			1	1	1			4										
2	18					2	1	6	1	1	3				3						1				
3	13					3	2	1	2	1			4												
4	2						1	1																	
5	8					1		1	2	2			1		1										
6	9					1	2	1	2			2		1											
7	6	1					1	1	1				1	1											
8	17					3	1		2	3		1		3		1		2					1		
9	14				1		2	1	2	3			2				3								
10	3				1			1					1												
11	3					1			1		1														
12	2						2																		
13	1							1																	
	758	1	1	1	7	25	44	69	89	83	94	73	68	57	34	32	27	13	12	8	6	5	5	2	2

	Days.
Average length of feeding period	21.64
Maximum length of feeding period	35
Minimum length of feeding period	12

TABLE X.—*Length of feeding period of larvæ of the first brood of the codling moth, bagged-fruit method, Grand Junction, Colo., 1915.*

Date of entering fruit.	Number of individuals.	Length of feeding period in specified days.																				
		15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
May 31	1																		1			
June 2	1											1										
3	8									3			1		3		1					
4	11									2	1	1		3		3			1			
5	6							2	2	1								1				
6	14							9	2	1	1		1									
7	15						1	7	1		2	1	1	1						1		
8	4												3	1								
9	11						1	3		1		1	2	1								2
10	6				2			2		1				1								
11	4				2		1		1													
12	1					1																
13	6					3				1		1	1									
14	8						2			1	2	1			1	1						
15	5						2	3														
16	6		1				2		1	1					1							
17	8					1		5		1		1										
18	11					1	2		1		3	1	1		1				1			
19	5				1				1		2	1										
20	3							1			1			1								
21	12							4	2	1	1	1			1	2						
22	1										1											
23	10	1			1			4	1	2	1											
24	8						1	1	1		2	1				1		1				
25	7							4								2					1	
26	7						2			2	1					2						
27	6						1		1	1		2			1							
28	11	1		1		3	1		2	1	2											
29	6				1	2	1		1			1										
30	8		2		2	1	1				1		1									
July 1	7					1	3	2				1										
2	18				7		3	3	1			2		2								
3	7				1		2	3	1													
	242	2	3	1	17	13	26	53	19	20	21	17	11	10	8	11	1	2	3	1	1	2

	Days.
Average length of feeding period	22.7
Maximum length of feeding period	35
Minimum length of feeding period	15

Length of the cocooning period.—The cocooning period is herein considered as extending from the time the larva leaves the fruit until it has pupated. The data given in Table XI, therefore, apply only to the transforming larvæ of the first brood. By reference to this table it will be seen that the cocooning period was recorded for 430 individuals which left the fruit from June 23 to July 26. Of this number, 86 formed their cocoon in 4 days, 85 in 5 days, and 67 in 6 days. The average number of days for all individuals was 6.70, maximum 28, and minimum 1. This minimum cocooning period of 1 day is the shortest period recorded for any larva throughout this and the following season. The cocoon was of normal size, but was constructed very lightly.

Table XI.—*Length of cocooning period of transforming codling moth larvæ of the first brood, Grand Junction, Colo., 1915.*

Larvæ left fruit.	Number of individuals.	Length of cocooning period in specified days, being the time from leaving the fruit to the time of pupation.																							Av.	Max.	Min.
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	17	18	19	20	22	23	26	28	*Days.*	*Days.*	*Days.*
June 23	1	...	...	...	1	...	...	...	...	...	...	...	..	..	..	..	..	..	..	..	..	..	..	..	4.00	4	4
25	1	...	...	...	...	...	1	...	...	...	...	...	..	..	..	..	..	..	..	..	..	..	..	..	6.00	6	6
26	10	...	...	...	3	3	3	...	...	...	...	1	..	..	..	..	..	..	..	..	..	..	..	..	5.60	11	4
27	21	...	...	2	10	6	...	1	2	...	...	...	..	..	..	..	..	..	..	..	..	..	..	..	4.71	8	3
28	18	...	...	2	3	8	2	...	3	...	...	...	..	..	..	..	..	..	..	..	..	..	..	..	5.22	8	3
29	14	...	1	1	3	4	...	3	...	2	...	...	..	..	..	..	..	..	..	..	..	..	..	..	5.43	9	2
30	10	...	...	...	2	2	2	...	3	...	...	...	1	..	..	..	..	..	..	..	..	..	..	..	6.60	12	4
July 1	31	...	1	1	7	9	6	4	1	...	...	...	..	..	..	1	1	..	..	..	..	..	..	..	5.87	17	2
2	27	1	...	1	7	6	6	2	2	...	...	2	..	..	..	..	..	..	..	..	..	..	..	..	5.55	11	1
3	17	...	...	1	2	3	4	4	...	1	...	...	..	..	..	..	..	1	..	..	..	..	..	1	7.82	28	3
4	17	...	1	...	2	3	2	2	1	...	2	1	1	..	..	1	..	..	1	..	..	..	..	..	8.00	19	2
5	17	...	...	...	2	2	2	2	2	1	...	...	1	..	1	..	..	..	..	1	2	1	..	..	10.70	23	4
6	35	...	...	4	8	6	5	3	...	1	1	...	1	2	1	..	2	..	..	..	..	..	1	..	7.31	26	3
7	18	...	...	...	6	2	3	3	2	...	...	...	..	2	..	..	..	..	..	..	..	..	..	..	6.39	13	4
8	28	...	...	3	3	6	6	...	...	3	2	2	1	1	..	1	..	..	..	..	..	..	..	..	7.00	15	3
9	20	...	...	1	2	4	2	3	2	1	3	...	1	..	1	..	..	..	..	..	..	..	..	..	7.25	14	3
10	14	...	...	...	3	2	...	1	3	1	...	2	..	..	..	1	..	..	..	..	1	..	..	..	8.64	22	4
11	15	...	1	...	2	...	3	3	3	...	...	2	..	..	..	1	..	..	..	..	..	..	..	..	7.33	15	2
12	17	...	...	1	2	3	1	4	...	2	2	...	..	2	..	..	..	..	..	..	..	..	..	..	7.29	13	3
13	8	...	...	...	2	...	...	2	1	2	1	...	..	..	..	..	..	..	..	..	..	..	..	..	7.25	10	4
14	10	...	...	...	2	2	2	1	2	1	...	...	..	..	..	..	..	..	..	..	..	..	..	..	6.20	9	4
15	13	...	...	...	1	3	1	3	2	...	2	1	..	..	..	..	..	..	..	..	..	..	..	..	7.15	11	4
16	10	...	...	...	4	2	2	...	...	...	1	...	1	..	..	..	..	..	..	..	..	..	..	..	6.00	12	4
17	10	...	...	1	1	...	3	1	2	...	...	1	..	1	..	..	..	..	..	..	..	..	..	..	7.20	13	3
18	10	...	1	2	2	1	...	2	...	...	2	...	..	..	..	..	..	..	..	..	..	..	..	..	5.50	10	2
19	9	...	...	1	1	3	4	...	...	...	...	...	..	..	..	..	..	..	..	..	..	..	..	..	5.11	6	3
20	11	...	...	2	1	3	1	...	2	...	1	...	1	..	..	..	..	..	..	..	..	..	..	..	6.27	12	3
21	5	...	...	...	2	1	1	...	...	...	...	1	..	..	..	..	..	..	..	..	..	..	..	..	5.00	11	4
22	6	...	...	...	1	...	2	...	2	...	...	...	..	1	..	..	..	..	..	..	..	..	..	..	7.50	13	4
23	2	...	...	...	...	...	1	...	1	...	...	...	..	..	..	..	..	..	..	..	..	..	..	..	7.00	8	6
24	2	...	...	...	...	1	...	...	1	...	...	...	..	..	..	..	..	..	..	..	..	..	..	..	6.50	8	5
25	1	...	...	...	1	...	...	...	...	...	...	...	..	..	..	..	..	..	..	..	..	..	..	..	4.00	4	4
26	2	...	...	...	...	...	2	...	...	...	...	...	..	..	..	..	..	..	..	..	..	..	..	..	6.00	6	6
Total.	430	1	5	23	86	85	67	44	37	15	17	13	8	9	3	5	3	1	1	1	3	1	1	1	6.70	28	1

Pupæ of the First Brood.

Time of pupation.—The earliest pupation of the transforming larvæ of the first brood occurred June 27, and the latest took place August 4. The larvæ were therefore pupating during a period of slightly more than one month. See Table XII and diagram, figure 5.

Length of pupal stage.—The average length of the pupal stage of pupæ of the first brood is considerably shorter (about 16 days) than that of the spring-brood pupæ, owing to the higher temperatures prevailing during midsummer. As given in Table XIII the average length of the first-brood pupal stage was 11.44 days, maximum 31 days, and minimum 6 days.

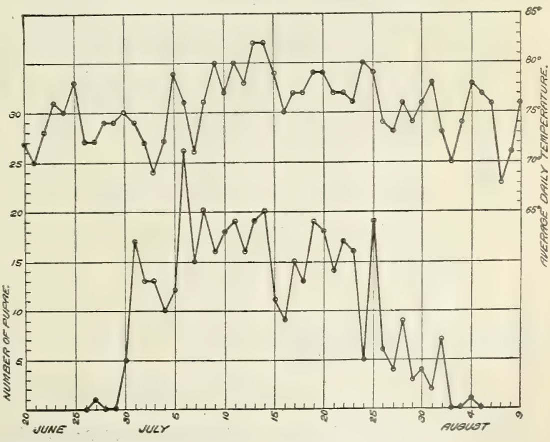


Fig. 5.—Time of pupation of first brood of the codling moth, Grand Junction, Colo., 1915.

TABLE XII.—*Time of pupation of transforming larvæ of the first brood of the codling moth, Grand Junction, Colo., 1915.*

Date of pupation.	Number of pupæ.	Date of pupation.	Number of pupæ.	Date of pupation.	Number of pupæ.	Date of pupation.	Number of pupæ.	Date of pupation.	Number of pupæ.
June 27	1	July 7	15	July 15	11	July 23	16	July 31	2
30	5	8	20	16	9	24	5	Aug. 1	7
July 1	17	9	16	17	15	25	19	2	0
2	13	10	18	18	13	26	6	3	0
3	13	11	19	19	19	27	4	4	1
4	10	12	16	20	18	28	9		
5	12	13	19	21	14	29	3	Total.....	432
6	26	14	20	22	17	30	4		

TABLE XIII.—*Length of the pupal stage of pupæ of the first brood of the codling moth, Grand Junction, Colo., 1915.*

Date of pupation.	Number of individuals.	Length of the pupal stage in specified days.																		
		6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	24	25	31
June 27	1	....	....	....	....	....	....	1	....	....	....	....	....	....	....	....	....	....	....	....
30	4	....	....	....	....	....	4	....	....	....	....	....	....	....	....	....	....	....	....	....
July 1	15	....	....	1	....	8	3	3	....	....	....	....	....	....	....	....	....	....	....	....
2	11	....	....	....	1	3	5	....	2	....	....	....	....	....	....	....	....	....	....	....
3	12	....	....	1	1	5	2	3	....	....	....	....	....	....	....	....	....	....	....	....
4	6	....	....	....	2	2	1	1	....	....	....	....	....	....	....	....	....	....	....	....
5	11	....	....	1	....	1	6	2	1	....	....	....	....	....	....	....	....	....	....	....
6	19	....	1	....	3	6	5	4	....	....	....	....	....	....	....	....	....	....	....	....
7	13	1	....	....	1	1	8	1	1	....	....	....	....	....	....	....	....	....	....	....
8	16	....	....	2	....	6	5	3	....	....	....	....	....	....	....	....	....	....	....	....
9	8	....	....	1	1	2	2	1	....	....	....	....	....	....	....	....	....	....	....	1
10	15	....	....	....	3	4	5	2	....	....	....	....	....	....	....	....	....	1	....	....
11	16	....	....	....	2	3	4	4	1	1	....	....	....	....	....	....	....	....	1	....
12	12	....	1	....	1	2	2	4	2	....	....	....	....	....	....	....	....	....	....	....
13	14	....	....	....	....	1	6	5	....	2	....	....	....	....	....	....	....	....	....	....
14	17	....	....	....	....	2	10	2	1	1	....	1	....	....	....	....	....	....	....	....
15	7	....	....	....	....	....	1	5	....	....	....	....	....	....	1	....	....	....	....	....
16	7	....	....	....	1	....	3	1	2	....	....	....	....	....	....	....	....	....	....	....
17	13	....	....	1	....	2	3	3	3	....	....	....	....	....	1	....	....	....	....	....
18	10	....	....	....	....	2	2	3	1	....	....	....	....	1	....	....	1	....	....	....
19	17	....	....	....	....	3	4	4	1	2	....	....	1	....	....	2	....	....	....	....
20	15	....	....	....	....	....	4	7	2	....	2	....	....	....	....	....	....	....	....	....
21	12	....	....	....	....	3	3	2	....	4	....	....	....	....	....	....	....	....	....	....
22	12	....	....	1	1	1	2	3	3	....	1	....	....	....	....	....	....	....	....	....
23	7	....	....	....	....	....	2	2	2	1	....	....	....	....	....	....	....	....	....	....
24	4	....	....	....	....	....	3	1	....	....	....	....	....	....	....	....	....	....	....	....
25	14	....	....	....	1	1	7	1	3	1	....	....	....	....	....	....	....	....	....	....
26	4	....	....	....	....	3	....	1	....	....	....	....	....	....	....	....	....	....	....	....
27	3	....	....	....	....	....	1	1	1	....	....	....	....	....	....	....	....	....	....	....
28	6	....	....	....	....	1	2	1	....	....	1	1	....	....	....	....	....	....	....	....
29	2	....	....	....	....	....	....	2	....	....	....	....	....	....	....	....	....	....	....	....
30	2	....	....	1	....	....	1	....	....	....	....	....	....	....	....	....	....	....	....	....
31	2	....	....	1	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Aug. 1	4	....	....	2	....	....	....	1	....	1	....	....	....	....	....	....	....	....	....	....
	331	1	2	12	19	62	106	74	26	13	4	2	1	1	2	2	1	1	1	1

	Days.
Average length of the pupal stage	11.44
Maximum length of the pupal stage	31
Minimum length of the pupal stage	6

MOTHS OF THE FIRST BROOD.

Time of emergence.—The records of the time of emergence of moths of the first brood were taken from two sources of material: (1) From moths that issued from first-brood larvæ reared in the insectary and (2) from moths that issued from the larvæ collected every three days from banded apple trees in the Hamilton orchard. The first of these sources was used primarily as a means of establishing the approximate emergence limits of the first-brood moths, while the moths that issued up to August 19 from the larvæ collected in the Hamilton orchard were used for the oviposition study of the first brood. The latter moths were employed for this purpose because their relative rate of emergence approaches normal field conditions more closely than that of the moths from the insectary reared larvæ.

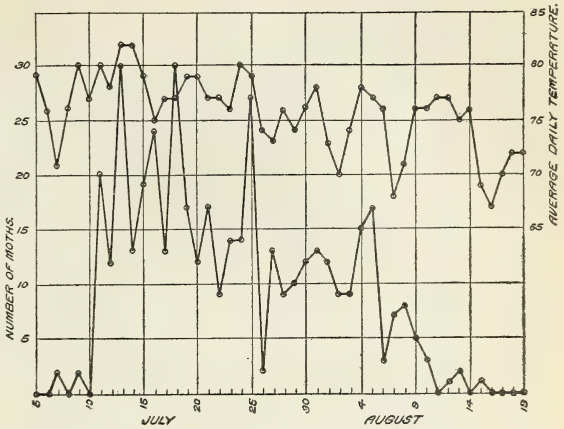


Fig. 6.—Time of emergence of moths of the first brood of the codling moth, Grand Junction, Colo., 1915.

According to the insectary-bred material, the first moth appeared July 7 and the emergence continued daily, except on a few days, to August 15. (See Table XIV and fig. 6.)

Table XIV.—*Time of emergence of codling moths of the first brood, from material reared at the insectary, Grand Junction, Colo., 1915.*

Date of emergence.	Number of moths.	Date of emergence.	Number of moths.	Date of emergence.	Number of moths.	Date of emergence.	Number of moths.
July 7	2	July 19	17	July 29	10	Aug. 7	7
9	2	20	12	30	12	8	8
11	20	21	17	31	13	9	5
12	12	22	9	Aug. 1	12	10	3
13	30	23	14	2	9	12	1
14	13	24	14	3	9	13	2
15	19	25	27	4	15	15	1
16	24	26	2	5	17		
17	13	27	13	6	3	Total..	426
18	30	28	9				

As given in Table XXV, the first moth of the second brood issued August 23, thus leaving a period from August 16 to 22, inclusive, during which no moths issued from larvæ reared at the insectary.

This condition did not obtain with the material from the Hamilton orchard on account of the much larger number of individuals involved, but instead moths issued continuously during the foregoing period as would naturally occur in the field. During the interval August 16 to 22 there was probably an overlapping of the broods and, for this reason, it was impossible to determine from field material when the last moth of the first brood emerged and when the first moth of the second brood appeared. It is reasonable to infer, however, that the approximate division of the broods occurred during the period of overlapping, and for this reason August 19 was selected as the end of the emergence of the first brood of moths. The time of emergence of the moths of the first brood from the larvæ collected in the Hamilton orchard is given in Table XV and presented graphically in figure 7. According to these data the first moths issued July 10, and emerged in maximum numbers on August 9.

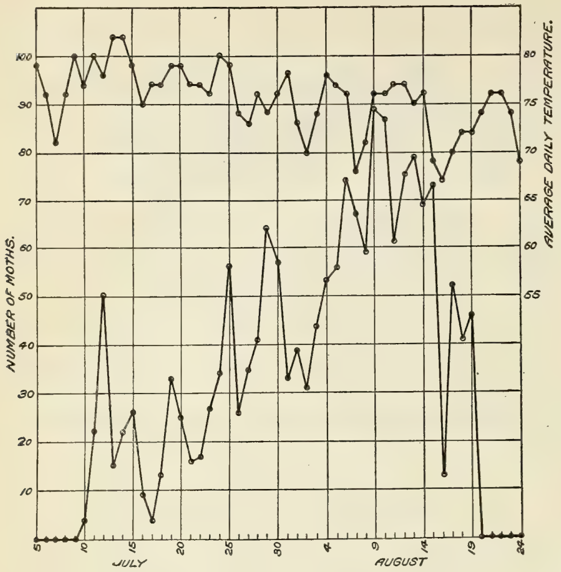


FIG. 7.—Time of emergence of moths of the first brood of the codling moth, Hamilton orchard, Grand Junction, Colo., 1915.

TABLE XV.—*Time of emergence of codling moths of the first brood, reared from field material, Grand Junction, Colo., 1915.*

Date of emergence.	Number of moths.	Date of emergence.	Number of moths.	Date of emergence.	Number of moths.	Date of emergence.	Number of moths.
July 10	4	July 21	16	Aug. 1	39	Aug. 12	75
11	22	22	17	2	31	13	79
12	50	23	27	3	44	14	69
13	15	24	34	4	53	15	73
14	22	25	56	5	56	16	13
15	26	26	26	6	74	17	52
16	9	27	35	7	67	18	41
17	4	28	41	8	59	19	46
18	13	29	64	9	89		
19	33	30	57	10	87	Total..	1,737
20	25	31	33	11	61		

Number of eggs per female moth.—It will be observed in Table XVI that the total number of eggs deposited by the 945 female moths of the first brood was 44,158 or 46.73 eggs per female moth. This average is nearly four times greater than that made by the spring-brood moths (12.59 eggs) owing, doubtless, to the more favorable climatic factors during the oviposition period of the first-brood moths.

Table XVI.—*Oviposition by codling moths of the first brood in rearing cages, Grand Junction, Colo., 1915.*

Cage No.	Number of moths.	Sex.		Date of—			Total number of eggs deposited.	Number of days—		
		Male.	Female.	Emergence of moths.	First oviposition.	Last oviposition.		Before oviposition.	From first to last oviposition.	From date of emergence to last oviposition.
1	24	10	14	July 12	July 13	July 24	797	1	12	12
2	26	17	9	...do....	July 14	July 25	679	2	12	13
3	15	11	4	July 13	...do....	...do....	501	1	12	12
4	22	11	11	July 14	July 16	July 24	390	2	9	10
5	26	14	12	July 15	...do....	July 28	351	1	13	13
6	9	7	2	July 16	....	....	(1)	....	....	....
7	4	2	2	July 17	July 20	July 31	74	3	12	14
8	13	3	10	July 18	...do....	Aug. 1	607	2	13	14
9	33	11	22	July 19	...do....	Aug. 5	1,475	1	17	17
10	25	12	13	July 20	July 22	Aug. 14	624	2	24	25
11	16	8	8	July 21	July 23	Aug. 5	767	2	14	15
12	17	9	8	July 22	July 24	Aug. 6	684	2	14	15
13	27	14	13	July 23	July 25	Aug. 18	427	2	25	26
14	34	12	22	July 24	...do....	Aug. 10	1,089	1	17	17
15	26	11	15	July 25	July 27	Aug. 13	860	2	18	19
16	30	15	15	...do....	...do....	Aug. 12	662	2	17	18
17	26	13	13	July 26	July 28	Aug. 8	602	2	12	13
18	35	12	23	July 27	July 29	Aug. 18	1,127	2	21	22
19	19	4	15	July 28	July 30	...do....	776	2	20	21
20	22	9	13	...do....	...do....	...do....	640	2	20	21
21	33	15	18	July 29	July 31	Aug. 14	517	2	15	16
22	31	10	21	...do....	...do....	Aug. 21	723	2	22	23
23	29	16	13	July 30	Aug. 1	Aug. 25	700	2	25	26
24	28	6	22	...do....	July 31	Aug. 19	737	1	20	20
25	12	6	6	July 31	Aug. 2	Aug. 16	229	2	15	16
26	21	8	13	...do....	Aug. 1	Aug. 20	641	1	20	20
27	18	7	11	Aug. 1	Aug. 5	Aug. 18	114	4	14	17
28	21	11	10	...do....	Aug. 4	...do....	382	3	15	17
29	31	13	18	Aug. 2	...do....	Aug. 26	694	2	23	24
30	22	8	14	Aug. 3	Aug. 5	Aug. 17	512	2	13	14
31	22	7	15	...do....	Aug. 6	Aug. 25	465	3	20	22
32	23	10	13	Aug. 4	...do....	Aug. 28	1,068	2	23	24
33	30	13	17	...do....	...do....	Aug. 22	903	2	17	18
34	30	14	16	Aug. 5	...do....	Aug. 27	703	1	22	22
35	26	16	10	...do....	...do....	Aug. 23	668	1	18	18
36	25	8	17	Aug. 6	Aug. 11	Aug. 22	171	5	12	16
37	22	8	14	...do....	Aug. 8	Aug. 24	1,185	2	17	18
38	27	17	10	...do....	Aug. 10	Aug. 25	200	4	16	19
39	35	18	17	Aug. 7	Aug. 9	Aug. 26	742	2	18	19
40	32	13	19	...do....	...do....	Aug. 28	1,434	2	20	21
41	34	15	19	Aug. 8	Aug. 10	Aug. 25	1,393	2	16	17
42	25	15	10	...do....	...do....	Aug. 29	684	2	20	21
43	26	13	13	Aug. 9	Aug. 11	Aug. 26	568	2	16	17
44	36	16	20	...do....	...do....	Aug. 22	990	2	12	13
45	27	12	15	...do....	Aug. 10	Aug. 28	838	1	19	19
46	34	14	20	Aug. 10	Aug. 12	Aug. 30	755	2	19	20
47	27	10	17	...do....	...do....	Aug. 26	350	2	15	16
48	26	17	9	...do....	...do....	Aug. 24	1,000	2	13	14
49	31	14	17	Aug. 11	Aug. 13	Sept. 2	622	2	21	22
50	30	16	14	...do....	...do....	Aug. 27	980	2	15	16
51	24	14	10	Aug. 12	Aug. 14	Aug. 28	436	2	15	16
52	29	9	20	...do....	...do....	...do....	701	2	15	16
53	22	6	16	...do....	Aug. 13	Aug. 31	456	1	19	19
54	27	10	17	Aug. 13	Aug. 15	Aug. 29	357	2	15	16
55	26	11	15	...do....	Aug. 16	Aug. 28	756	3	13	15
56	26	13	13	...do....	Aug. 15	...do....	591	2	14	15
57	24	14	10	Aug. 14	Aug. 19	Sept. 1	372	5	14	18
58	23	6	17	...do....	Aug. 16	Aug. 31	583	2	16	17
59	22	8	14	...do....	Aug. 15	Aug. 29	700	1	15	15
60	25	10	15	Aug. 15	Aug. 17	Sept. 9	1,103	2	24	25
61	22	11	11	...do....	Aug. 18	Sept. 1	749	3	15	17
62	26	11	15	...do....	Aug. 17	Sept. 2	403	2	17	18
63	13	5	8	Aug. 16	Aug. 21	Aug. 27	29	5	7	11
64	25	12	13	Aug. 17	Aug. 18	Sept. 1	299	1	15	15
65	27	16	11	...do....	Aug. 19	Aug. 28	473	2	10	11
66	21	9	12	Aug. 18	Aug. 20	Sept. 7	502	2	19	20
67	20	9	11	...do....	...do....	Sept. 12	639	2	24	25
68	22	12	10	Aug. 19	Aug. 22	Sept. 7	340	3	17	19
69	24	9	15	...do....	Aug. 20	Sept. 12	565	1	24	24
Average								2.07	16.78	17.85
Maximum								5	25	26
Minimum								1	7	10

---

[1] No eggs.

Number of male moths	766	Total number of eggs	44,158
Number of female moths	945	Average number of eggs per female moth	46.73
Total number of moths	1,711		

Time of oviposition.—One of the most important problems in connection with the control of the codling moth in the Grand Valley was to determine when the earliest eggs of the second brood were deposited and when oviposition was at its height. It is believed that these data could best be secured by using moths that emerged from larvæ collected regularly from banded orchard trees, since the subsequent emergence of the moths would correspond to that which would naturally have occurred in the field. With this in view, the moths from the Hamilton orchard material were kept for oviposition studies, beginning with those that emerged July 12 and ending with those that issued August 19.

As is given in Table XVI, 69 cages containing a total of 1,711 moths were employed and, as will be noted therein, the average number of days before oviposition was 2.07, maximum 5, and minimum 1; the average number of days from the first to the last oviposition was 16.78, maximum 25, and minimum 7; the average number of days from the date of emergence to last oviposition was 17.85, maximum 26, and minimum 10.

According to this table the first eggs were deposited July 13 by moths that emerged July 12 and the last eggs were laid September 12. A few moths issued July 10 and 11 from the Hamilton orchard material, and, in addition to these, several moths emerged from insectary-bred and other material as early as July 7. These moths were confined together in a cage and deposited the earliest second-brood eggs on July 11, as shown in figure 8, page 31.

Length of life of moths.—Table XVII includes the summary of records of the length of life of 1,719 male and female moths of the first brood. The data in this table show that the average length of life of 769 male moths was 11.86 days, of 950 female moths 12.68 days; the maximum length of life of male moths 41 days, of female moths 35 days; the minimum length of life of male moths 1 day, of female moths 1 day. As has been frequently observed in other studies of the life history of the codling moth with but few exceptions, the average life of the female moth is longer than that of the male.

Table XVII.—*Length of life of male and female codling moths of the first brood in captivity; summary of records of 1,719 individual moths, Grand Junction, Colo., 1915.*

Male.		Female.		Male.		Female.		Male.		Female.	
Length of life.	Number of moths.	Length of life.	Number of moths.	Length of life.	Number of moths.	Length of life.	Number of moths.	Length of life.	Number of moths.	Length of life.	Number of moths.
Days.		*Days.*		*Days.*		*Days.*		*Days.*		*Days.*	
1	4	1	1	16	26	16	64	31	1	31	0
2	8	2	2	17	29	17	39	32	0	32	0
3	24	3	10	18	27	18	36	33	0	33	0
4	15	4	10	19	10	19	21	34	0	34	0
5	44	5	16	20	12	20	20	35	0	35	1
6	48	6	35	21	16	21	13	36	1	36	0
7	55	7	35	22	7	22	16	37	1	37	0
8	55	8	61	23	6	23	7	38	1	38	0
9	38	9	72	24	7	24	7	39	0	39	0
10	68	10	75	25	8	25	3	40	0	40	0
11	49	11	103	26	7	26	5	41	1	41	0
12	58	12	96	27	4	27	3				
13	45	13	74	28	3	28	3	Total.	769	Total.	950
14	39	14	65	29	2	29	3				
15	46	15	54	30	4	30	0				

Average length of life of male moths, 11.86 days; female moths, 12.68 days.
Maximum length of life of male moths, 41 days; female moths, 35 days.
Minimum length of life of male moths, 1 day; female moths, 1 day.

Life Cycle of the First Generation.

Life cycle, stock-jar feeding method.—The length of the life cycle of the first generation of the codling moth, by the stock-jar feeding method, is given in Table XVIII and, as shown therein, includes the time from the deposition of the egg to the emergence of the moth. The complete life cycle extends from the deposition of the eggs of one generation to the deposition of the eggs of the next, and it will therefore be necessary to add 2.07 days, the average number of days from emergence of moth to first oviposition, to the figures in Table XVIII to determine the complete life cycle. It will be noted in this table that the data include 221 individuals, giving the incubation period, and the average, maximum, and minimum length of the larval feeding period, the cocooning period, the pupal period, and the life cycle. The summarized averages are: Incubation period 9.91 days, larval feeding period 20.75 days, cocooning period 6.99 days, pupal period 11.64 days, and life cycle 49.30 days, complete life cycle 51.37 days.

Life cycle, bagged-fruit feeding method.—In Table XIX the life cycle of the first generation of the codling moth, by the bagged-fruit method, is given for 109 individuals. The summarized average figures are: Incubation period 10.55 days, larval feeding period 22.18 days, cocooning period 5.40 days, pupal period 11.03 days, life cycle 49.18 days, complete life cycle 51.25 days.

TABLE XVIII.—*Life cycle of the first generation of the codling moth, as observed by rearing, stock-jar feeding method, Grand Junction, Colo., 1915.*

Date of egg deposition.	Number of individuals.	Incubation.	Larval feeding period.			Cocooning period.			Pupal period.			Life cycle.[1]		
			Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.
		Days.	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*
May 13	1	14	27.00	27	27	4.00	4	4	12.00	12	12	57.00	57	57
23	4	13	22.25	23	21	3.50	5	3	10.25	11	8	49.00	50	47
24	11	13	21.45	25	19	5.36	11	2	10.81	13	6	50.63	54	48
24	1	14	20.00	20	20	4.00	4	4	11.00	11	11	49.00	49	49
26	2	13	20.00	21	19	5.00	8	2	9.00	10	8	47.00	48	46
27	9	13	19.77	23	18	5.22	9	3	10.33	12	8	48.33	53	45
29	11	12	20.63	22	18	5.09	7	3	11.27	13	10	49.00	51	45
29	15	13	21.80	27	19	6.66	9	3	13.26	31	9	54.73	72	47
31	3	12	20.66	22	19	14.33	28	4	10.66	12	9	57.66	70	46
June 1	2	12	20.50	21	20	7.00	7	7	10.00	11	9	49.50	51	48
2	12	12	21.08	25	18	9.25	23	3	11.33	13	7	53.66	66	46
4	31	11	19.83	27	14	6.77	20	3	11.45	20	7	49.06	65	39
6	15	10	22.20	32	18	8.40	14	4	13.13	21	9	53.73	63	45
9	20	8	20.55	26	15	7.55	14	2	11.60	14	8	47.70	56	38
10	23	8	20.86	29	17	7.17	13	4	11.47	15	9	47.52	56	40
11	13	8	20.84	26	19	6.84	13	3	12.38	25	10	48.07	57	42
12	10	8	21.20	24	18	7.60	11	4	12.10	16	10	48.90	53	45
13	6	8	21.00	24	19	6.66	9	4	12.50	14	11	48.16	52	45
15	3	7	24.66	29	20	10.33	11	9	9.66	11	8	51.66	55	46
16	3	7	22.66	25	20	6.66	10	2	12.00	14	10	48.33	50	46
16	1	8	18.00	18	18	5.00	5	5	13.00	13	13	44.00	44	44
18	1	7	21.00	21	21	12.00	12	12	11.00	11	11	51.00	51	51
19	3	7	20.00	24	17	7.66	9	6	12.00	15	10	46.66	54	42
20	2	7	18.50	20	17	5.00	6	4	11.00	12	10	41.50	45	38
21	6	7	21.50	26	16	7.16	9	4	11.16	12	10	46.83	53	44
21	4	8	17.50	19	15	6.50	8	5	11.00	12	10	43.00	46	38
23	2	7	19.50	20	19	8.50	12	5	9.50	11	8	44.50	47	42
25	1	7	16.00	16	16	5.00	5	5	11.00	11	11	39.00	39	39
26	3	7	18.33	23	16	6.00	6	6	12.66	14	11	44.00	50	40
27	2	7	17.50	18	17	6.00	6	6	12.00	12	12	42.50	43	42
30	1	6	17.00	17	17	6.00	6	6	12.00	12	12	41.00	41	41
	221	9.91	20.75	32	14	6.99	28	2	11.64	31	6	49.30	72	38

[1] Add 2.07 days for complete life cycle.

TABLE XIX.—*Life cycle of the first generation of the codling moth, as observed by rearing, bagged-fruit feeding method, Grand Junction, Colo., 1915.*

Date of egg deposition.	Number of individuals.	Incubation.	Larval feeding period.			Cocooning period.			Pupal period.			Life cycle.[1]		
			Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.
		Days.	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*
May 16	1	15	32.00	32	32	5.00	5	5	10.00	10	10	62.00	62	62
22	1	11	25.00	25	25	4.00	4	4	10.00	10	10	50.00	50	50
23	5	11	26.40	30	23	4.80	6	4	11.00	12	10	53.20	59	49
23	8	12	27.37	32	23	6.25	15	3	10.62	13	9	56.25	63	50
23	5	13	21.80	23	21	4.60	6	4	10.40	11	10	49.80	51	49
24	8	13	21.12	22	21	4.12	5	3	10.75	13	9	49.00	52	48
24	9	14	22.22	25	21	5.66	8	4	10.55	12	9	52.44	57	49
26	3	13	26.33	27	26	7.33	12	4	9.00	11	8	55.66	60	51
27	6	13	23.66	27	20	9.33	22	1	12.33	17	10	58.33	74	49
29	4	12	19.50	21	18	7.00	8	6	10.25	11	9	48.75	50	47
29	2	13	19.00	20	18	5.00	5	5	11.50	12	11	48.50	50	47
31	1	12	19.00	19	19	4.00	4	4	11.00	11	11	46.00	46	46
June 1	5	12	21.20	26	19	4.80	6	4	10.80	12	9	48.80	55	44
2	2	12	21.50	23	20	3.00	4	2	11.50	12	11	48.00	51	45
4	3	11	20.33	21	20	4.66	5	4	11.00	12	10	47.00	48	46
6	5	10	21.40	28	16	5.40	8	4	9.60	11	8	46.40	54	42
9	4	8	20.50	21	19	4.25	5	3	11.50	13	10	44.25	46	41
10	3	8	22.33	28	19	9.66	15	6	13.33	15	11	53.33	57	46
13	8	8	23.25	29	21	4.75	7	4	12.75	19	11	48.75	53	44
16	4	8	21.75	24	20	4.25	5	4	11.75	12	11	45.75	48	43
18	1	7	21.00	21	21	5.00	5	5	12.00	12	12	45.00	45	45
19	4	7	22.50	24	20	4.50	6	3	10.75	12	10	44.75	47	43
21	3	7	17.00	19	15	4.33	5	4	10.66	11	10	39.00	41	36
21	3	8	21.33	25	19	4.66	5	4	11.66	12	11	45.66	50	43
23	3	7	18.00	20	16	4.00	5	3	10.00	11	9	39.00	41	38
24	4	7	20.50	21	20	4.75	6	4	12.25	16	10	44.50	50	42
25	4	7	18.75	21	18	6.50	10	3	10.00	13	8	42.25	44	41
	109	10.55	22.18	32	15	5.40	22	1	11.03	19	8	49.18	74	36

[1] Add 2.07 days for complete life cycle.

THE SECOND GENERATION.

EGGS OF THE SECOND BROOD.

Time of deposition.—Table XX shows the number of eggs deposited daily by moths of the first brood in oviposition jars in the insectary. It will be noted that the period of egg deposition extended from July 11 to September 15, inclusive, and that during this interval 38,485 eggs were deposited. The largest number deposited in any one day was 2,452 on August 14, as will be seen by reference to this table. The time of maximum deposition, as shown in figure 8, occurred about midway between the earliest and latest deposition.

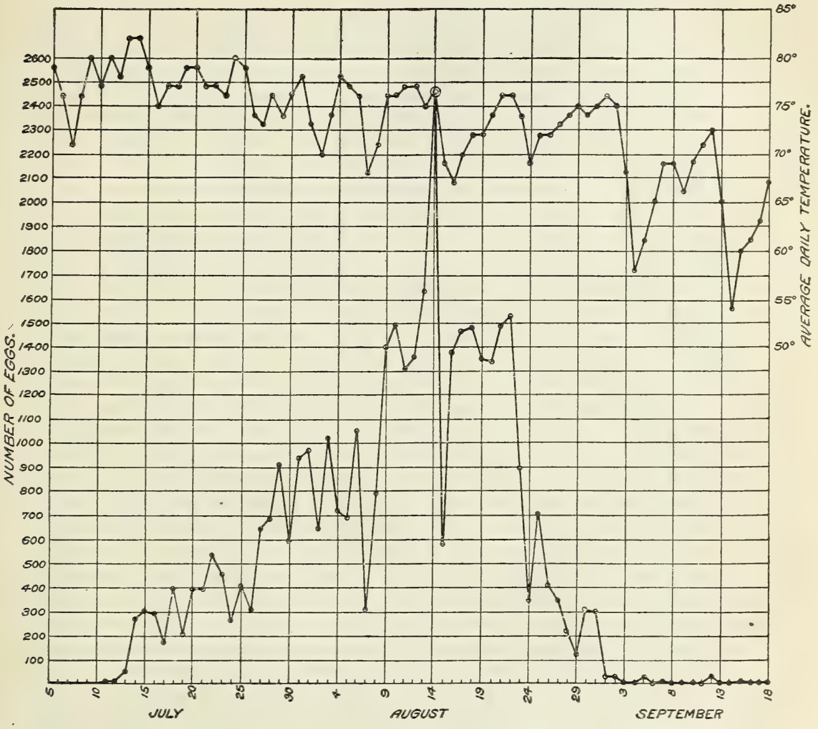


FIG. 8.—Time of deposition of eggs of the second brood of codling moth, Grand Junction, Colo., 1915.

TABLE XX.—*Time of deposition, length of incubation, and time of hatching of eggs of the second brood of the codling moth, Grand Junction, Colo., 1915.*

Observation No.	Number of eggs deposited.	Date—				Number of eggs hatched.	Appearance of—		Incubation period.
		Deposited.	Red ring.	Black spot.	Hatched.		Red ring.	Black spot.	
							Days.	*Days.*	*Days.*
1	6	July 11	July 13			0	2		
2	10	July 12	...do....	July 17	July 19	8	1	5	7
3	53	July 13	July 14	July 16	...do...	50	1	3	6
4					July 20	2			7
5	271	July 14	July 15	July 19	...do....	179	1	5	6
6					July 21	43			7
7	303	July 15	July 16	July 20	...do....	170	1	5	6
8	288	July 16	July 17	July 21	July 22	282	1	5	6
9	176	July 17	July 18	...do....	July 23	169	1	4	6
10	398	July 18	July 19	July 23	July 24	378	1	5	6
11					July 25	16			7
12	208	July 19	July 20	July 23	July 24	94	1	4	5
13					July 25	106			6
14	396	July 20	July 21	July 24	July 26	376	1	4	6
15					July 27	12			7
16	395	July 21	July 22	July 25	July 26	51	1	4	5
17					July 27	300			6
18	539	July 22	July 24	July 26	...do....	32	2	4	5
19					July 28	496			6
20	455	July 23	July 25	July 28	July 29	446	2	5	6
21					July 30	5			7
22	261	July 24	July 25	July 28	...do....	245	1	4	6
23					July 31	13			7
24	404	July 25	July 28	July 30	...do....	315	3	5	6
25					Aug. 1	57			7
26	309	July 26	July 28	July 31	...do....	250	2	5	6
27					Aug. 2	15			7
28	645	July 27	July 28	Aug. 1	...do....	555	1	5	6
29					Aug. 3	58			7
30	684	July 28	July 31	Aug. 2	...do....	588	3	5	6
31					Aug. 4	62			7
32	909	July 29	July 31	Aug. 3	...do....	709	2	5	6
33					Aug. 5	64			7
34	595	July 30	Aug. 1	Aug. 4	...do....	303	2	5	6
35					Aug. 6	256			7
36	937	July 31	Aug. 2	Aug. 5	...do....	581	2	5	6
37					Aug. 7	311			7
38	966	Aug. 1	Aug. 3	Aug. 6	...do....	58	2	5	6
39					Aug. 8	831			7
40	641	Aug. 2	Aug. 4	Aug. 7	...do....	340	2	5	6
41					Aug. 9	244			7
42					Aug. 10	38			8
43	1,013	Aug. 3	Aug. 5	Aug. 8	Aug. 9	223	2	5	6
44					Aug. 10	760			7
45	720	Aug. 4	Aug. 6	Aug. 9	...do....	554	2	5	6
46					Aug. 11	137			7
47	693	Aug. 5	Aug. 6	Aug. 10	...do....	464	1	5	6
48					Aug. 12	194			7
49	1,045	Aug. 6	Aug. 8	Aug. 11	...do....	543	2	5	6
50					Aug. 13	408			7
51	314	Aug. 7	Aug. 10	Aug. 12	...do....	223	3	5	6
52					Aug. 14	69			7
53	787	Aug. 8	Aug. 10	Aug. 13	...do....	401	2	5	6
54					Aug. 15	299			7
55	1,400	Aug. 9	Aug. 10	Aug. 14	...do....	1,064	1	5	6
56					Aug. 16	224			7
57	1,495	Aug. 10	Aug. 11	Aug. 15	...do....	837	1	5	6
58					Aug. 17	493			7
59					Aug. 18	75			8
60	1,311	Aug. 11	Aug. 12	Aug. 16	Aug. 17	105	1	5	6
61					Aug. 18	1,091			7
62					Aug. 19	66			8
63	1,358	Aug. 12	Aug. 13	Aug. 17	Aug. 18	81	1	5	6
64					Aug. 19	1,127			7
65					Aug. 20	95			8
66	1,626	Aug. 13	Aug. 14	Aug. 19	...do....	1,480	1	6	7
67	2,452	Aug. 14	Aug. 16	Aug. 20	Aug. 21	2,280	2	6	7
68	583	Aug. 15	Aug. 17	Aug. 21	Aug. 22	501	2	6	7
69					Aug. 23	52			8
70	1,378	Aug. 16	Aug. 18	Aug. 21	Aug. 22	978	2	5	6
71					Aug. 23	289			7
72	1,462	Aug. 17	Aug. 20	Aug. 22	...do....	1,067	3	5	6
73					Aug. 24	380			7
74	1,485	Aug. 18	Aug. 20	Aug. 23	...do....	1,292	2	5	6
75					Aug. 25	163			7

TABLE XX.—*Time of deposition, length of incubation, and time of hatching of eggs of the second brood of the codling moth, Grand Junction, Colo., 1915*—Continued.

Observation No.	Number of eggs deposited.	Date—				Number of eggs hatched.	Appearance of—		Incubation period.
		Deposited	Red ring.	Black spot.	Hatched.		Red ring.	Black spot.	
							Days.	*Days.*	*Days.*
76	1,353	Aug. 19	Aug. 21	Aug. 24	Aug. 25	352	2	5	6
77					Aug. 26	947			7
78	1,340	Aug. 20	Aug. 22	Aug. 25	do	456	2	5	6
79					Aug. 27	616			7
80	1,490	Aug. 21	Aug. 24	Aug. 26	do	45	3	5	6
81					Aug. 28	1,341			7
82	1,526	Aug. 22	Aug. 24	Aug. 27	do	889	2	5	6
83					Aug. 29	504			7
84	895	Aug. 23	Aug. 26	Aug. 29	Aug. 30	841	3	6	7
85	343	Aug. 24	do	Aug. 30	Aug. 31	278	2	6	7
86					Sept. 1	38			8
87	702	Aug. 25	Aug. 27	Aug. 30	Aug. 31	407	2	5	6
88					Sept. 1	288			7
89	412	Aug. 26	Aug. 28	Sept. 1	Sept. 2	325	2	6	7
90					Sept. 3	21			8
91	348	Aug. 27	Aug. 28	Sept. 1	do	282	1	5	7
92					Sept. 5	28			9
93	224	Aug. 28	Aug. 29	Sept. 2	Sept. 3	146	1	5	6
94					Sept. 4	11			7
95					Sept. 5	45			8
96	129	Aug. 29	Aug. 31	Sept. 4	do	18	2	6	7
97					Sept. 6	59			8
98					Sept. 7	31			9
99	309	Aug. 30	Sept. 1	Sept. 6	do	133	2	7	8
100					Sept. 8	154			9
101					Sept. 9	19			10
102	300	Aug. 31	Sept. 1	Sept. 7	Sept. 8	171	1	7	8
103					Sept. 9	93			9
104					Sept. 10	21			10
105	35	Sept. 1	Sept. 3	Sept. 8	do	30	2	7	9
106					Sept. 11	4			10
107	29	Sept. 2	Sept. 6	Sept. 10	do	22	4	8	9
108					Sept. 12	6			10
109	28	Sept. 5	Sept. 8	Sept. 13	Sept. 14	22	3	8	9
110					Sept. 15	1			10
111					Sept. 16	1			11
112	4	Sept. 6	Sept. 8	Sept. 14	Sept. 15	3	2	8	9
113					Sept. 16	1			10
114	7	Sept. 7	Sept. 9	Sept. 15	do	1	2	8	9
115					Sept. 17	1			10
116	2	Sept. 8	Sept. 11	Sept. 17	Sept. 18	2	3	9	10
117	3	Sept. 9	do	do	Sept. 19	2	2	8	10
118					Sept. 20	1			11
119	2	Sept. 10	Sept. 12	Sept. 18	do	2	2	8	10
120	32	Sept. 12	Sept. 14	Sept. 20	Sept. 22	26	2	8	10
121	1	Sept. 15	Sept. 18	Sept. 23	Sept. 24	1	3	8	9
Total	38,485					35,804			
Av.							1.85	5.54	7.22
Max.							4	8	11
Min.							1	3	6

Length of incubation.—A record of the observations of the embryological development and incubation period of the eggs of the second brood will be found in Table XX. It will be observed that the length of the incubation period was increased toward the latter part of the season, as the temperatures became lower. The average number of days from the time of deposition to the appearance of the red ring was 1.85, maximum 4 days, and minimum 1 day; the average number of days from the time of deposition to the appearance of the black spot was 5.54 days, maximum 8 days, and minimum 3 days; the average length of the incubation period was 7.22 days, maximum 11 days, and minimum 6 days.

LARVÆ OF THE SECOND BROOD.

Time of hatching.—By reference to Table XX it will be seen that the time of hatching of eggs of the second brood extended over a period of more than two months, namely, from July 19 to September 24. The largest number hatching in any one day was 2,280 on August 21, a date which is just midway between that when the first larvæ of this brood appeared and the date when the last larva hatched. In figure 9 the daily hatching record is shown diagrammatically with average daily temperatures.

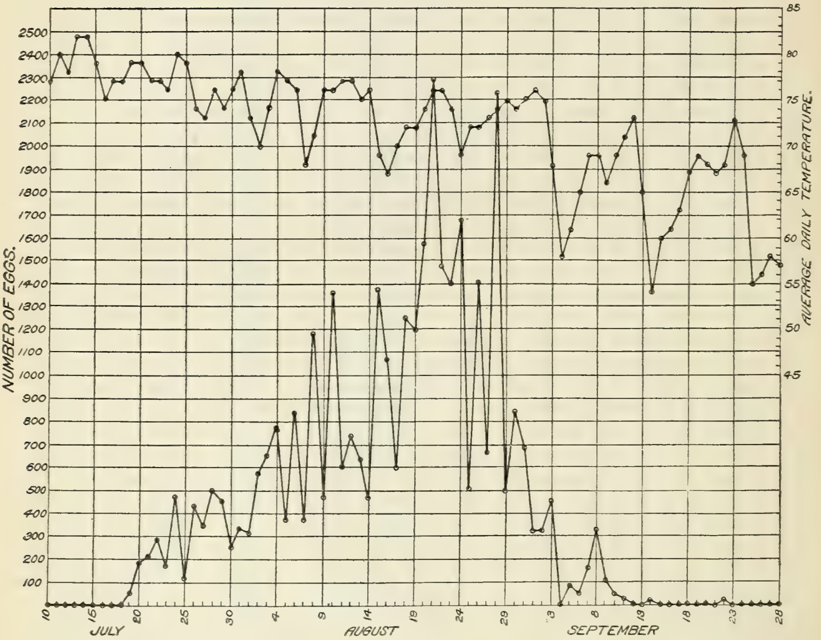


FIG. 9.—Time of hatching of eggs of the second brood of the codling moth, Grand Junction, Colo., 1915.

Length of the feeding period.—The length of the feeding period of larvæ of the second brood was established by means of the stock-jar method (see p. 8). The observations of 1,939 larvæ are presented in Table XXI, in which it will be noted that the feeding periods during the warmer weather of July and August were considerably shorter than those during September and October. The first larvæ of the second brood entered the fruit July 19, and although some of the larvæ hatched and commenced feeding as late as September 24, none that entered the fruit later than September 12 successfully completed its feeding period. The average length of the feeding period was 28.69 days, the maximum 67 days, and the minimum 15 days.

TABLE XXI.—*Length of feeding period of larvæ of the second brood of the codling moth, stock-jar method, Grand Junction, Colo., 1915.*

Date of entering fruit.	Number of individuals.	Length of feeding period in specified days.																							
		15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
July 19	20			3	1	2	2		3	2		2	2	1	1		1								
20	43		1	1	1	2	5	7	4	4	4	3	3	2	3	2				1					
21	81		1	5	2	10	12	5	5	7	5	4	3	2	5	2	3		3		5		1		1
22	74				2	7	6	8	13	8	4	3	7	2	3	5	4			1			1		
23	28					2	1	5	3		1	1	3	1	3	2	1		2		1			2	
24	67			1	1	6		15	10	9	6	2	2		3	5			1	1	1			1	1
25	20				2		2	3	2	5		1	1		2	1			1						
26	48					2	6		5	7	2	11	3	1	2		4		2			1	2		
27	44				1	2	2	2	9	2	5	3	2	2	1	3	2	2	1	1	1	3			
28	38			2		1	4	5	6	3		7	4				1	1			2	1			
29	50				2		5	7	4	6	6	3	2	4	3	1			5		2				
30	39					1	3	4	4	3	5	7	4	2	1	1				1		2		1	
31	58					4	11	10	5	6	5	3	5	1	1	2	3	1	1						
Aug. 1	52	1			2	3	4	7	4	5	5	3	4	2	1	4	1	1	1		1			1	
2	62		1			1	5	10	5	7	7	4	6	1	3	3	3		2	2			1		
3	52					2	4	1	11	2	6	7	6	4	3	2		1			1	2			
4	37					1	1	4	2	4	4	3	3	2	3	3	2	2	1	1				1	
5	56						2	5	3	4	7	4	7	8	2	3	1	2	2		3	1			1
6	64							2	1	12	6	7	7	5	2	2	2	4	3		2	2		2	
7	51		1					3	4	5	13	5	4	3	1		2	1	1		1		1		1
8	·81						3	7	13	6	16	9	2	4	5	2	1	2	2		2			1	2
9	55						1	11	7	7	8	3	2	2	2		2	2	2			4			
10	57				3	1	3	2	3	6	8	2	2	5	1	2	4	1	1	3	4	1			
11	28			1			2	2	3	3	1	2		3	2		3								3
12	47					3	4	4	6	2	1	2	1	6	4	4		5	1		3				
13	49				1		2	1	2	3	6	6	3	1	3	3	6	2			3				1
14	38					5	2			7	1	2	7			4	1			1	1	1			4
15	35				1				2		4	4	3	2	1	2			2	1	5	1	2		
16	44						1			1	8	4	6	2	6		1			2	1	2	3	1	2
17	29					1		1	4		2	5	2	2	5			1							1
18	40					1				2	3	7	1		2	3	2	1	3	3	2	2		3	
19	39								1	1	10		1	1	2		4	2	2	1	3	5	1	1	
20	34									1	5	4	1		4	6		1	1	3	2	1			1
21	41												3	10	9	5		4	2	1	3				1
22	2																		2						
23	22									1	1	1		3	1	1	6	2	6						
24	21							1			1			2	2	2	2	2				2		2	1
25	27									1	1	1	1	4	4	1	1	2		2	2				2
26	40												4	2	1	3	3	2	2	6				1	
27	29												3	2	4	1			2		1	2			1
28	21													2	3	3	1		3	1		1	1		
29	32												3	1		3			1	5	3	1		1	2
30	24													1	1	2		1	2	1	1		2	1	
31	21													1		1	2	2		2					
Sept. 1	17																		2						
		1	4	13	19	57	93	132	144	142	167	135	123	99	105	89	69	47	62	40	56	35	15	19	25

TABLE XXI.—*Length of feeding period of larvæ of the second brood of the codling moth, stock-jar method, Grand Junction, Colo., 1915*—Continued.

Date of entering fruit.	Number of individuals.	Length of feeding period in specified days.																												
		39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
July 24	67	2																												
28	38		1																											
Aug. 1	52	1	1																											
2	62	1																												
5	56										1																			
6	64	2		1			1					1																		
7	51	1		1		1	1		1																					
8	81			1	1	1				1																				
9	55											2																		
10	57				1	1								3																
11	28	2	1																											
12	47		1																											
13	49	2	1		1		1	1																						
14	38	1	1																											
15	35		3			1	1																							
16	44		1				2	1																						
17	29	1			1			1	2																					
18	40		1	1		3																								
19	39	1		1	2																									
20	34	2	1	1																										
21	41	1					1			1																				
24	21	2	1	1																										
25	27	1			2													1				1								
26	40		1	1		2	1	1	1	4	1								2		2									
27	29	3		1	1		1	1		3		1						1			1								1	
28	21		1				2											1	2											
29	32	4		1	1													4			1						1			
30	24	1	2		3			1		3												2								
31	21		2	2		1		1			1			1		2			1	2										
Sept. 1	17		1	3						1			3	1	2	2			1						1					
2	12			1				1		1	1		1		1	1							1	2			1			1
3	16		2			2		1	1	1	1				1								3		1	2	1			
4	12	2			1					1						1		1			2	3			1					
5	8							1	1		1							1			1					1		1		1
6	10				1			1		1						1	1				1			3				1		
7	8							1			1	2	1		1			1	1											
8	3														2					1										
9	9						1							1			2	1	1	1		1				1				
10	3														1						2									
12	1																1													
	1,939	29	22	16	15	12	12	12	6	17	7	6	5	6	8	7	4	11	8	4	10	7	4	5	3	4	3	2	1	2

	Days.
Average length of feeding period	28.69
Maximum length of feeding period	67
Minimum length of feeding period	15

Length of the cocooning period.—The time consumed in constructing the cocoon by the transforming larvæ of the second brood will be found in Table XXII. As will be noted therein, the average cocooning period for 20 individuals was 9.35 days, the maximum 31 days, and the minimum 3 days. The maximum here reported is the longest cocooning period secured for any larva throughout this and the following season. As will be seen from Table XXII, this individual left the fruit September 1 and pupated October 2.

TABLE XXII.—*Length of cocooing period of transforming larvæ of the second brood of the codling moth, Grand Junction, Colo., 1915.*

Larvæ left fruit.	Number of individuals.	Length of cocooning period in specified days, being the time from leaving the fruit to the time of pupation.											Average.	Maximum.	Minimum.
		3	4	5	6	7	8	10	11	12	16	31			
													Days.	*Days.*	*Days.*
Aug. 5	2	....	....	....	....	....	....	1	....	1	....	....	11.00	12	10
7	1	....	....	....	....	....	....	....	....	1	....	....	12.00	12	12
8	1	....	1	....	....	....	....	....	....	....	....	....	4.00	4	4
9	1	....	....	1	....	....	....	....	....	....	....	....	5.00	5	5
10	1	....	....	....	1	....	....	....	....	....	....	....	6.00	6	6
11	1	....	....	....	....	....	....	1	....	....	....	....	10.00	10	10
12	1	1	....	....	....	....	....	....	....	....	....	....	3.00	3	3
13	1	....	....	....	....	....	....	....	....	....	1	....	16.00	16	16
16	2	....	....	....	1	1	....	....	....	....	....	....	6.50	7	6
19	1	....	....	....	1	....	....	....	....	....	....	....	6.00	6	6
20	3	....	....	....	....	1	1	1	....	....	....	....	8.33	10	7
22	1	....	....	1	....	....	....	....	....	....	....	....	5.00	5	5
28	1	....	....	....	....	....	....	....	....	1	....	....	12.00	12	12
Sept. 1	1	....	....	....	....	....	....	....	....	....	....	1	31.00	31	31
3	1	....	....	....	....	....	....	....	1	....	....	....	11.00	11	11
7	1	....	....	....	1	....	....	....	....	....	....	....	6.00	6	6
Total.	20	1	1	2	4	2	1	3	1	3	1	1	9.35	31	3

PUPÆ OF THE SECOND BROOD.

Time of pupation.—It will be observed in Table XXIII and figure 10 that pupation of the second brood occurred from August 12 to October 2, inclusive.

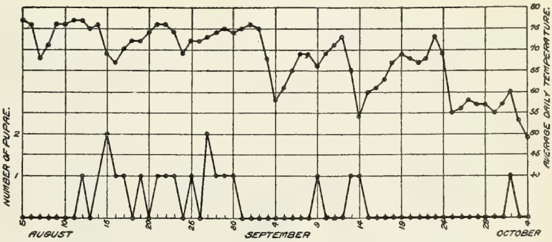


FIG. 10.—Time of pupation of the second brood of the codling moth, Grand Junction, Colo., 1915.

Length of the pupal stage.—In Table XXIV the length of the pupal stage of 16 pupæ of the second brood is given and, as recorded therein, the average was 15.62 days, the maximum 31 days, and the minimum 11 days.

TABLE XXIII.—*Time of pupation of transforming larvæ of the second brood of the codling moth, Grand Junction, Colo., 1915.*

Date of pupation.	Number of pupæ.	Date of pupation.	Number of pupæ.	Date of pupation.	Number of pupæ.	Date of pupation.	Number of pupæ.
Aug. 12	1	Aug. 19	1	Aug. 27	2	Sept. 13	1
14	1	21	1	28	1	14	1
15	2	22	1	29	1	Oct. 2	1
16	1	23	1	30	1		
17	1	25	1	Sept. 9	1	Total..	20

TABLE XXIV.—*Length of the pupal stage of pupæ of the second brood of the codling moth, Grand Junction, Colo., 1915.*

Date of pupation.	Number of individuals.	Length of the pupal stage in specified days.							
		11	12	13	14	16	19	21	31
Aug. 12	1	1							
14	1	1							
15	1				1				
17	1		1						
19	1			1					
22	1					1			
23	1				1				
25	1			1					
27	2				2				
28	1							1	
29	1				1				
30	1						1		
Sept. 9	1				1				
13	1								1
14	1						1		
	16	2	1	2	6	1	2	1	1

	Days.
Average length of pupal stage	15.62
Maximum length of pupal stage	31
Minimum length of pupal stage	11

MOTHS OF THE SECOND BROOD.

Time of emergence.—The time of emergence of moths of the second brood reared from insectary-bred material is presented in Table XXV and figure 11. The first moth of this brood issued August 23, the last October 14; thus the emergence extended over a period of more than one and a half months.

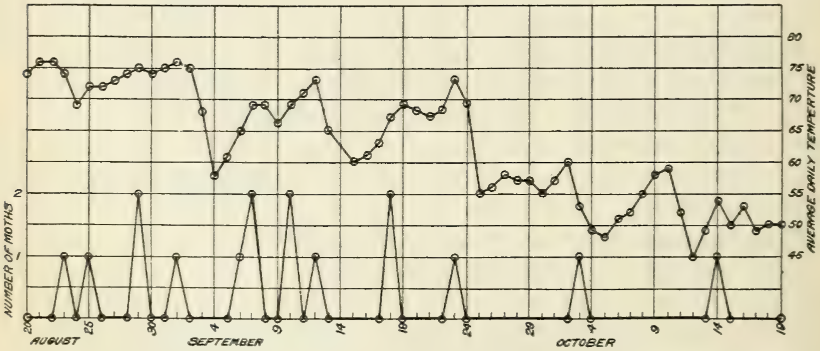


FIG. 11.—Time of emergence of moths of the second brood of the codling moth, Grand Junction, Colo., 1915.

TABLE XXV.—*Time of emergence of codling moths of the second brood, Grand Junction, Colo., 1915.*

Date of emergence.	Number of moths.	Date of emergence.	Number of moths.
Aug. 23	1	Sept. 12	1
25	1	18	2
29	2	23	1
Sept. 1	1	Oct. 3	1
6	1	14	1
7	2		
10	2	Total...	16

LIFE CYCLE OF THE SECOND GENERATION.

In Table XXVI are given the summarized data showing the average length of each period in the life cycle of the codling moth as derived from observations of 16 individuals of the second generation reared by the stock-jar feeding method. It will be noted that the average length of the incubation period was 6.12 days, the larval feeding period 20.49 days, the cocooning period 8.56 days, the pupal period 15.62 days, and the average life cycle 50.81 days.

TABLE XXVI.—*Life cycle of the second generation of the codling moth, as observed by rearing by the stock-jar feeding method, Grand Junction, Colo., 1915.*

Date of egg deposition.	Number of individuals.	Incubation.	Larval feeding period.			Cocooning period.			Pupal period.			Life cycle.		
			Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.
		Days.	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*
July 13	2	6	18.50	20	17	8.00	12	4	11.50	12	11	44.00	47	41
14	3	6	19.33	24	16	12.66	16	10	13.66	14	13	51.66	60	46
16	2	6	21.50	25	18	5.50	6	5	13.50	16	11	46.50	53	40
21	1	6	20.00	20	20	7.00	7	7	14.00	14	14	47.00	47	47
25	4	6	19.75	20	19	7.75	10	6	16.75	21	13	50.25	55	44
27	1	6	20.00	20	20	5.00	5	5	14.00	14	14	45.00	45	45
31	1	6	28.00	28	28	11.00	11	11	19.00	19	19	64.00	64	64
Aug. 3	1	7	18.00	18	18	12.00	12	12	14.00	14	14	51.00	51	51
6	1	7	25.00	25	25	6.00	6	6	31.00	31	31	69.00	69	69
	16	6.12	20.49	28	16	8.56	16	4	15.62	31	11	50.81	69	40

THE THIRD GENERATION.

Owing to the small number of moths of the second brood that were reared at the insectary, data of the third generation were not secured. The moths of the second brood deposited third-brood eggs but none of these hatched. Complete data of the third generation, however, were obtained in 1916 (see p. 75–78).

CODLING-MOTH BAND STUDIES OF 1915.

Two orchards were selected for banding purposes. The first of these, known as the Edwards orchard, was unsprayed; it was located about one-half mile west of the insectary. The second, or Hamilton orchard, was well sprayed throughout the season, and was located about 2 miles west and 3½ miles north of the insectary. Certain trees in each orchard were scraped to remove the loose bark on the trunk and larger limbs and were then banded with a strip of burlap cloth, folded to three thicknesses, having a width after folding of about 5 inches. These bands were removed every three days with one exception in both orchards when the interval was four days. The larvæ of each collection were kept separate and were allowed to spin up in corrugated pasteboard strips at the insectary for further study.

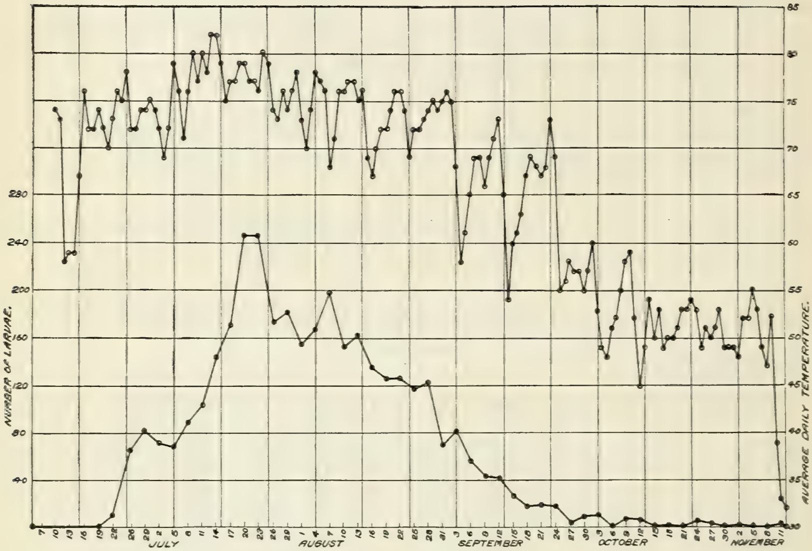


FIG. 12.—Number of larvæ of the codling moth collected from banded trees, Edwards orchard, Grand Junction, Colo., 1915.

In Table XXVII and figure 12 will be found the data for the Edwards orchard. As noted therein, the first larval collection was made June 22 and the last November 11, and during this period 3,551 larvæ were secured. The maximum number of larvæ collected at any one time was 250, and this number was successively obtained on July 20 and 23. During the season of 1915, 1,417 moths, or 39.96 per cent. of the total number of larvæ collected, issued from the band material. The percentage of moths emerging from each collection is shown in figure 13. No moths from this orchard emerged in 1915 from larvæ collected after August 16 In the following spring 976, or 27.52 per cent, of the moths emerged. The remainder of the larvæ, 32.52 per cent, failed to transform to the adult stage.

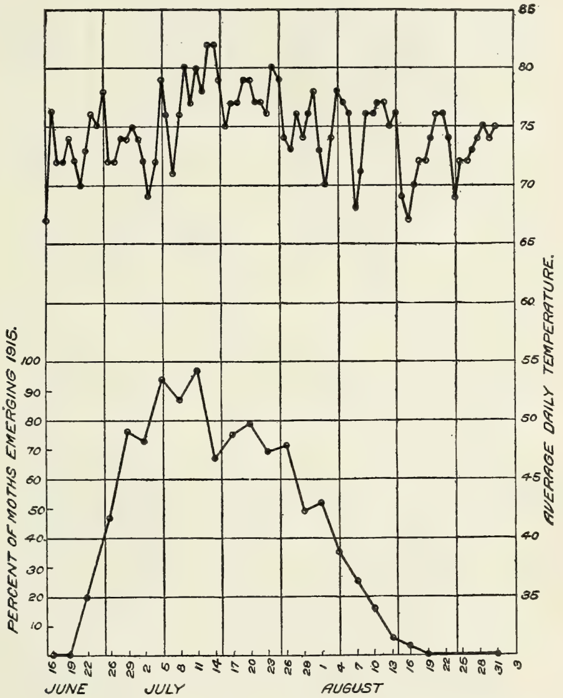


FIG. 13.—Percentage of codling moths emerging from band-collected material, Edwards orchard, Grand Junction, Colo., 1915.

TABLE XXVII.—*Band-record experiment. Codling moth larvæ collected at the Edwards orchard, Grand Junction, Colo., 1915.*

Date of collection, 1915.	Collection No.	Number of larvæ collected.	Total number of moths emerging, 1915.	Total number of moths emerging, 1916.	Per cent of—		
					Moths emerging, 1915.	Moths emerging, 1916.	Dead individuals.
June 22	1	10	2	0	20.00	0	80.00
26	2	66	31	0	46.96	0	53.04
29	3	82	62	0	75.60	0	24.40
July 2	4	[1] 72	51	0	[4] 72.80	0	[4] 27.15
5	5	[2] 69	63	0	[4] 94.02	0	[4] 5.98
8	6	89	77	0	86.51	0	13.49
11	7	[3] 104	100	1	[4] 97.08	[4] 0.97	[4] 1.95
14	8	144	97	0	67.36	0	32.64
17	9	171	128	1	74.85	0.58	24.57
20	10	250	197	3	78.80	1.20	20.00
23	11	250	173	9	69.20	3.60	27.20
26	12	173	123	10	71.09	5.78	23.13
29	13	182	89	17	48.90	9.34	41.76
Aug. 1	14	155	80	37	51.61	23.87	24.52
4	15	167	58	55	34.73	32.94	32.33
7	16	198	49	85	24.74	42.97	32.29
10	17	153	24	43	15.68	28.10	56.22
13	18	162	9	50	5.55	30.86	63.59
16	19	135	4	100	2.96	74.07	22.97
19	20	126	0	63	0	50.00	50.00
22	21	127	0	78	0	61.41	38.59
25	22	117	0	88	0	75.21	24.79
28	23	123	0	81	0	65.85	34.15
31	24	70	0	44	0	62.85	37.15
Sept. 3	25	82	0	54	0	65.85	34.15
6	26	56	0	40	0	71.42	28.58
9	27	44	0	34	0	27.27	22.73
12	28	42	0	13	0	30.95	69.05
15	29	27	0	15	0	55.55	44.45
18	30	18	0	11	0	61.11	38.89
21	31	19	0	13	0	68.42	31.58
24	32	18	0	8	0	44.44	55.56
27	33	4	0	1	0	25.00	75.00
30	34	9	0	2	0	22.22	77.78
Oct. 3	35	10	0	7	0	70.00	30.00
6	36	0	0	0	0	0	0
9	37	7	0	4	0	57.14	42.86
12	38	6	0	1	0	16.66	83.34
15	39	1	0	1	0	100.00	0
18	40	1	0	1	0	100.00	0
21	41	0	0	0	0	0	0
24	42	5	0	1	0	20.00	80.00
27	43	3	0	3	0	1.00	0
30	44	0	0	0	0	0	0
Nov. 2	45	2	0	1	0	50.00	50.00
5	46	0	0	0	0	0	0
8	47	0	0	0	0	0	0
11	48	2	0	1	0	50.00	50.00
Total larvæ...		3,551	....	....	....	....	....
Total moths..		....	1,417	976	[4] 39.96	[4] 27.52	[4] 32.52

[1] A larva killed in handling; 1 killed by predatory spider.
[2] 2 larvæ killed in handling.
[3] 1 larva killed in handling.
[4] All percentages based upon number of live larvæ collected.

The data in connection with the band studies made at the Hamilton orchard are shown in Table XXVIII and figure 14. The earliest collection was made June 28; the latest, October 21 following the final harvest of the fruit. A total of 4,183 larvæ was collected from which 2,092 moths, or 50.01 per cent, emerged in 1915. No moths issued during the season of 1915 from any larvæ that were collected in this orchard after August 19. For the percentage of moths issuing in 1915 from each collection of larvæ see figure 15. In the spring of 1916, 869 moths issued, or 20.77 per cent of the total number of larvæ collected. The rest of the material, 29.22 per cent, did not reach the adult stage.

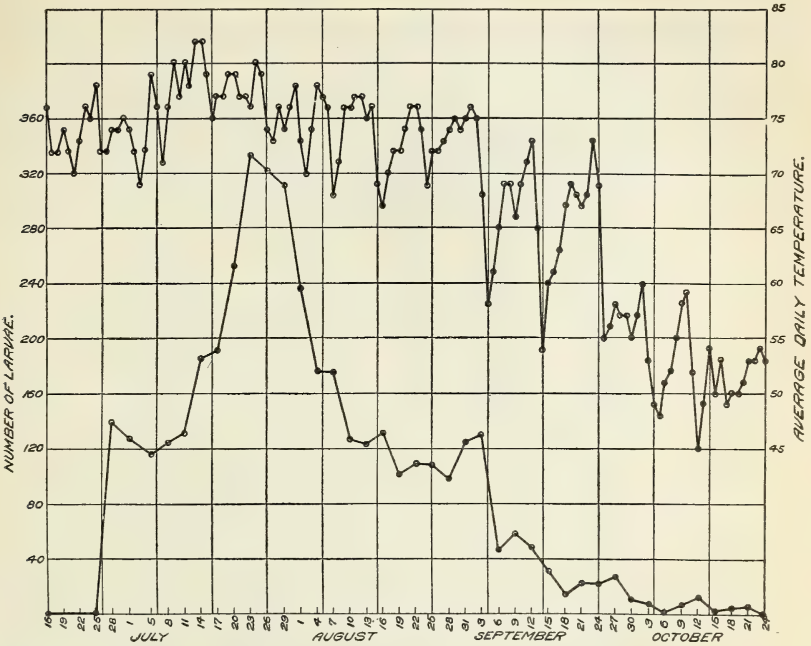


FIG. 14.—Number of larvæ of codling moth collected from banded trees, Hamilton orchard, Grand Junction, Colo., 1915.

Under field, or normal, conditions, there is a distinct overlapping of the larvæ of the first and second broods and of the second and third broods and similarly the moths of the first and second broods overlap. Hence with larvæ collected in the field it is impossible to know at all times to which brood the individuals belong. But with the insects reared at the insectary the brood identity

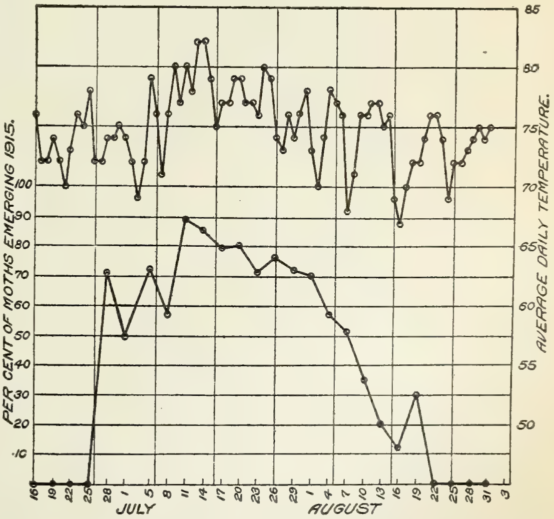


FIG. 15.—Percentage of codling moths emerging from band-collected material, Hamilton orchard, Grand Junction, Colo., 1915.

of each individual is definitely known, and this information aids in the establishment of the approximate limits of the broods as they occur in the field.

TABLE XXVIII.—*Band-record experiment. Codling moth larvæ collected at the Hamilton orchard, Grand Junction, Colo., 1915.*

Date of collection, 1915.	Collection No.	Number of larvæ collected.	Total number of moths emerging, 1915.	Total number of moths emerging, 1916.	Per cent of— Moths emerging, 1915.	Moths emerging, 1916.	Dead individuals.
June 28	1	138	98	0	71.01	0	28.99
July 1	2	127	63	0	49.60	0	50.40
5	3	116	84	0	72.41	0	27.59
8	4	124	71	0	57.25	0	42.75
11	5	130	116	0	89.23	0	10.77
14	6	185	158	2	85.40	1.08	13.52
17	7	191	151	1	79.05	5.23	15.72
20	8	252	201	3	79.76	1.19	19.05
23	9	333	238	8	71.47	2.40	26.13
26	10	322	245	8	76.08	2.48	21.44
29	11	311	225	14	72.34	4.50	23.16
Aug. 1	12	235	165	13	70.21	5.53	24.26
4	13	176	101	25	57.38	14.20	28.42
7	14	176	89	53	50.56	30.11	19.33
10	15	127	44	31	34.64	24.40	40.96
13	16	123	24	37	19.51	30.08	50.41
16	17	131	16	51	12.21	38.93	48.86
19	18	101	3	54	29.70	53.46	16.84
22	19	109	0	54	0	49.54	50.46
25	20	108	0	82	0	75.92	24.08
28	21	98	0	81	0	82.65	17.35
31	22	123	0	76	0	61.78	38.22
Sept. 3	23	129	0	100	0	77.51	22.49
6	24	46	0	26	0	56.52	43.48
9	25	58	0	30	0	51.72.	48.28
12	26	48	0	22	0	45.83	54.17
15	27	31	0	16	0	51.16	48.39
18	28	14	0	11	0	78.57	21.43
21	29	23	0	15	0	65.21	34.79
24	30	22	0	13	0	59.09	40.91
27	31	27	0	18	0	66.66	33.34
30	32	11	0	8	0	72.72	27.28
Oct. 3	33	8	0	4	0	50.00	50.00
6	34	1	0	0	0	0	100.00
9	35	6	0	2	0	33.33	66.67
12	36	12	0	7	0	58.33	41.67
15	37	2	0	1	0	50.00	50.00
18	38	4	0	2	0	50.00	50.00
21	39	5	0	1	0	20.00	80.00
Total larvæ...		4,183	....	....	....	....	....
Total moths...		....	2,092	869	50.01	20.77	29.22

In figure 16 is presented the total combined number of moths emerging daily from the larvæ collected in the Edwards and Hamilton orchards during the season of 1915. As will be observed therein, the moths began to emerge on July 9 and continued their emergence until September 8, except on September 4 and 6, when no moths issued. The maximum emergence, 152 moths, issued August 6. The total number of moths emerging from this combined material in 1915 was 3,509 and in the spring of 1916, 1,845, or 45.37 per cent and 23.86 per cent, respectively, of the total number of larvæ collected. The rest of the larvæ, 2380, or 30.77 per cent, died over winter or through injury as a result of handling or from other undetermined causes.

The life-history data obtained in 1915 are shown in diagram in figure 17.

SEASONAL-HISTORY STUDIES OF 1916.

During the season of 1916 the life-history studies of the codling moth were continued along the same lines as in the preceding year. In several instances, however, the work was elaborated somewhat, since the amount of material on hand was a little larger than in 1915. The biology of the codling moth in 1916 was quite similar to that of 1915, except that the second generation began somewhat earlier in the season. Full data on the third brood were obtained.

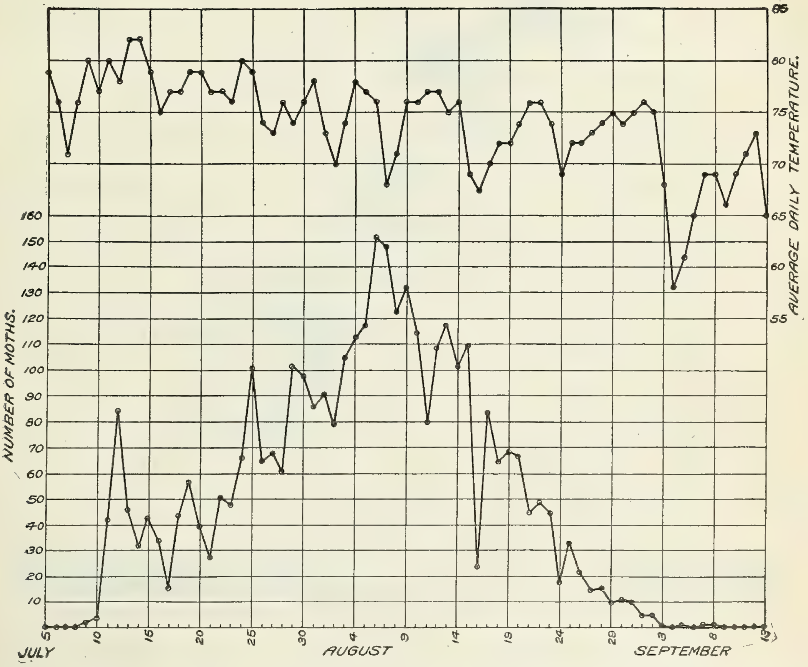


FIG. 16.—Time of emergence of codling moths from band-collected material, Hamilton and Edwards orchards, Grand Junction, Colo., 1915.

The blooming period of apple trees occurred in 1916 about the same time as in the previous year and, as in 1915, was followed by a little freezing weather. On the morning of June 30 the temperature dropped to 27° or 28° F. in some parts of the valley, while on the next morning the temperature was about 1° lower. At this time about 85 to 90 per cent of the blossoms had dropped in the orchards of the Fruitvale district. While some injury resulted from these freezes, it was not sufficient to cause a serious crop loss. Frost rings and pits, the latter being in the calyx cavity, developed in much of the fruit, however, and, as a result, the codling moth larvæ frequently entered the fruit through these frost pits.

PUPÆ OF THE SPRING BROOD.

Time of pupation.—The daily observations of the time of pupation of the wintering larvæ are tabulated in Table XXIX and presented graphically in figure 18. Reference to this table will show that 508 larvæ were under observation and that the earliest pupation occurred April 16 and the latest June 12, the period thus covering about two months. The maximum pupation took place May 6, when 37 individuals pupated. On April 28, 36 larvæ transformed to pupæ, and if weather conditions had continued normal for the remainder of the month, it is probable that the maximum pupation would have occurred about May 1; but, as will be seen in the graph, the

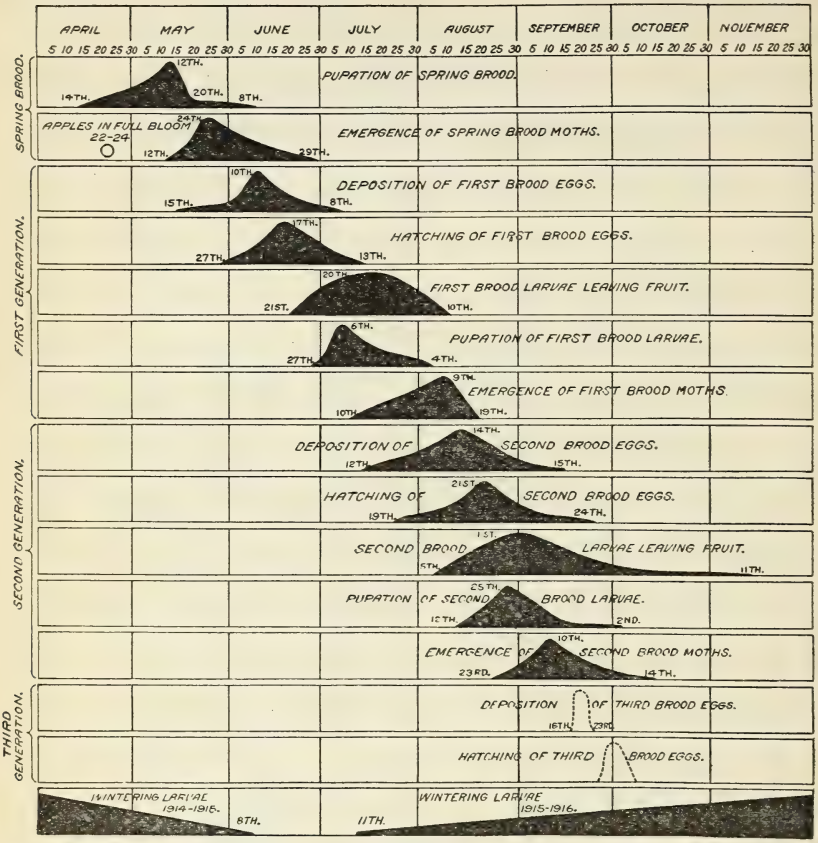

APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
5 10 15 20 25 30
SPRING BROOD.
FIRST GENERATION.
SECOND GENERATION.
THIRD GENERATION.
14TH.
12TH.
20TH.
8TH.
PUPATION OF SPRING BROOD.
APPLES IN FULL BLOOM 22-24
24TH.
12TH.
29TH.
EMERGENCE OF SPRING BROOD MOTHS.
10TH.
15TH.
8TH.
DEPOSITION OF FIRST BROOD EGGS.
17TH.
27TH.
13TH.
HATCHING OF FIRST BROOD EGGS.
20TH.
21ST.
10TH.
FIRST BROOD LARVAE LEAVING FRUIT.
6TH.
27TH.
4TH.
PUPATION OF FIRST BROOD LARVAE.
9TH.
10TH.
19TH.
EMERGENCE OF FIRST BROOD MOTHS.
14TH.
12TH.
15TH.
DEPOSITION OF SECOND BROOD EGGS.
21ST.
19TH.
24TH.
HATCHING OF SECOND BROOD EGGS.
1ST.
5TH.
11TH.
SECOND BROOD LARVAE LEAVING FRUIT.
25TH.
12TH.
2ND.
PUPATION OF SECOND BROOD LARVAE.
10TH.
23RD.
14TH.
EMERGENCE OF SECOND BROOD MOTHS.
16TH.
23RD.
DEPOSITION OF THIRD BROOD EGGS.
HATCHING OF THIRD BROOD EGGS.
WINTERING LARVAE 1914-1916.
8TH.
11TH.
WINTERING LARVAE 1915-1916.

FIG. 17.—Diagram of life history of the codling moth in the Grand Valley of Colorado, 1915.

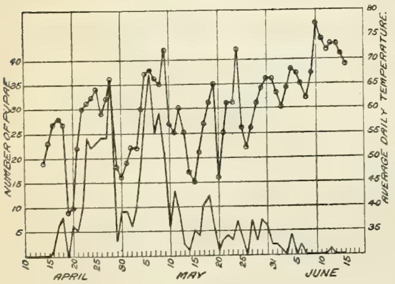


FIG. 18.—Time of pupation of spring brood of the codling moth, Grand Junction, Colo., 1916.

temperature dropped considerably, resulting in a check to the pupation activity.

TABLE XXIX.—*Time of pupation of wintering larvæ of the codling moth, Grand Junction, Colo., 1916.*

Date of pupation.	Number of pupæ.	Date of pupation.	Number of pupæ.	Date of pupation.	Number of pupæ.	Date of pupation.	Number of pupæ.	Date of pupation.	Number of pupæ.
Apr. 16	1	Apr. 27	24	May 8	29	May 19	6	May 30	6
17	6	28	36	9	21	20	1	31	2
18	8	29	3	10	6	21	3	June 1	2
19	0	30	9	11	13	22	4	2	1
20	6	May 1	9	12	8	23	3	3	0
21	5	2	6	13	2	24	7	4	4
22	10	3	10	14	1	25	3	5	0
23	24	4	18	15	5	26	0	6	2
24	22	5	29	16	4	27	7	12	1
25	23	6	37	17	10	28	3		
26	24	7	25	18	12	29	7	Total.	508

Length of the pupal stage.—The length of the pupal stage of the pupæ of the spring brood was computed from 390 individuals, beginning with five larvæ that pupated April 17 and ending with one that pupated June 12. The results of the observations are given in Table XXX, in which it will be noted that, as the season advanced with its higher temperatures, the pupal stage became shorter. Nearly 20 per cent of the pupæ were in the pupal stage 27 days, while the average length of this stage for all of the pupæ was 26.80 days with a range of from 13 to 36 days.

TABLE XXX.—*Length of the pupal stage of pupæ of the spring brood of the codling moth, Grand Junction, Colo., 1916.*

Date of pupation.	Number of individuals.	Length of the pupal stage in specified days.																				
		13	14	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	34	36
Apr. 17	5	...	...	...	...	...	...	...	...	...	...	...	1	2	...	...	1	1	...	...	...	...
18	7	...	...	...	...	...	...	...	...	...	...	...	1	...	...	1	3	1	1	...	...	...
20	4	...	...	...	...	...	...	...	...	...	...	...	...	...	3	...	1	...	...	...	...	...
21	6	...	...	...	...	...	...	...	...	...	...	...	...	...	2	4	...	...	...	...	...	...
22	8	...	...	...	...	...	...	...	...	...	...	...	1	...	5	...	...	1	...	...	...	1
23	18	...	...	...	...	...	...	...	...	...	...	...	1	2	...	1	12	2	...	...	...	...
24	18	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	7	9	...	...	...	...
25	17	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	12	3	...	...	...	...
26	19	...	...	...	...	...	...	...	...	...	...	...	...	...	1	11	4	3	...	...	...	...
27	18	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3	3	5	6	1	...	...
28	26	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	2	10	10	2	1	...
29	3	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	2	...	...	...	...
30	5	...	...	...	...	...	...	...	...	1	...	...	...	...	...	1	1	1	1	...	...	...
May 1	7	...	...	...	...	...	...	...	...	...	...	...	...	...	...	6	1	...	...	...	...	...
2	5	...	...	...	...	...	...	...	...	...	...	...	...	...	2	3	...	...	...	...	...	...
3	5	...	...	...	...	...	...	...	...	...	...	...	...	1	3	1	...	...	...	...	...	...
4	13	...	...	...	...	...	...	...	...	...	...	...	1	4	5	3	...	...	...	...	...	...
5	25	...	...	...	...	...	...	...	...	...	...	...	1	6	15	...	2	...	...	1	...	...
6	33	...	...	...	...	...	...	...	...	...	...	1	...	10	6	13	2	1	...	...	...	...
7	20	...	...	...	1	...	...	...	...	...	...	...	...	1	12	6	...	...	...	...	...	...
8	22	...	...	...	...	...	...	...	...	...	...	...	...	1	9	8	4	...	...	...	...	...
9	13	...	...	...	...	...	...	...	...	...	...	...	...	1	3	7	2	...	...	...	...	...
10	6	...	...	...	...	...	...	...	...	...	...	...	...	...	5	...	1	...	...	...	...	...
11	12	...	...	...	...	...	...	...	...	...	1	...	...	3	4	4	...	...	...	...	...	...
12	6	...	...	...	...	...	...	...	...	...	...	...	...	1	4	1	...	...	...	...	...	...
13	1	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...
14	1	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...

TABLE XXX.—*Length of the pupal stage of pupæ of the spring brood of the codling moth, Grand Junction, Colo., 1916*—Continued.

Date of pupation.	Number of individuals.	Length of the pupal stage in specified days.																				
		13	14	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	34	36
May 15	4	...	...	...	...	...	...	...	...	...	...	3	...	1	...	...	...	...	...	...	...	...
16	3	...	...	...	...	...	...	...	...	...	1	2	...	...	...	...	...	...	...	...	...	...
17	7	...	...	...	...	...	...	...	...	...	4	2	...	...	...	...	...	...	...	...	1	...
18	9	...	...	...	...	...	...	...	...	3	3	1	1	1	...	...	...	...	...	...	...	...
19	4	...	...	...	...	...	...	...	1	1	2	...	...	...	...	...	...	...	...	...	...	...
20	1	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...
21	2	...	...	...	...	...	...	...	2	...	...	...	...	...	...	...	...	...	...	...	...	...
22	3	...	...	...	...	...	...	1	1	...	1	...	...	...	...	...	...	...	...	...	...	...
23	3	...	...	...	...	...	...	2	...	...	...	...	...	1	...	...	...	...	...	...	...	...
24	5	...	...	...	...	2	1	...	2	...	...	...	...	...	...	...	...	...	...	...	...	...
25	2	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...
27	4	...	...	...	...	4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
28	2	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
29	5	...	...	1	2	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
30	6	...	...	...	6	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
31	1	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
June 2	1	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
4	2	...	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
6	2	...	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
12	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pupæ....	390	1	2	3	11	10	2	3	6	6	12	9	8	37	80	77	58	40	18	4	2	1

	Days.
Average length of pupal stage	26.8
Maximum length of pupal stage	36
Minimum length of pupal stage	13

MOTHS OF THE SPRING BROOD.

Time of emergence.—The tabulated data of the time of emergence of 4,808 moths of the spring brood are given in Table XXXI. The first of these emerged May 10 and the emergence period continued until June 28, when the last moth of this brood issued. The emergence reached its maximum on May 24, on which day 552 moths appeared. On the preceding day, May 23, the next highest in number, 432 moths, issued. The retardation of emergence, as caused by adverse climatic factors on May 20, is readily seen by the marked decrease in emergence from 309 moths May 19 to 3 moths May 20. The daily rate of emergence is shown in figure 19.

TABLE XXXI.—*Time of emergence of codling moths of the spring brood, Grand Junction, Colo, 1916.*

Date of emergence.	Number of moths.	Date of emergence.	Number of moths.	Date of emergence.	Number of moths.	Date of emergence.	Number of moths.	Date of emergence.	Number of moths.
May 10	3	May 21	13	June 1	169	June 11	74	June 21	1
11	10	22	368	2	80	12	58	22	5
12	21	23	432	3	146	13	42	23	1
13	49	24	552	4	150	14	43	24	3
14	8	25	151	5	120	15	29	25	2
15	4	26	135	6	97	16	26	26	1
16	39	27	160	7	45	17	17	27	0
17	36	28	274	8	86	18	17	28	1
18	162	29	247	9	79	19	11		
19	309	30	283	10	53	20	14	Total....	4,808
20	3	31	179						

Oviposition by moths of the spring brood.—The data obtained from the oviposition studies of 1,449 female moths confined in 123 cages with 1,292 male moths are presented in Table XXXII. The summarized figures give for the average number of days from the time of emergence to day of first oviposition 6.07, maximum 13 days, minimum 2 days; average number of days of oviposition 13.38, maximum 32 days, minimum 1 day; average number of days from the date of emergence to last oviposition 18.46, maximum 34 days, minimum 7 days.

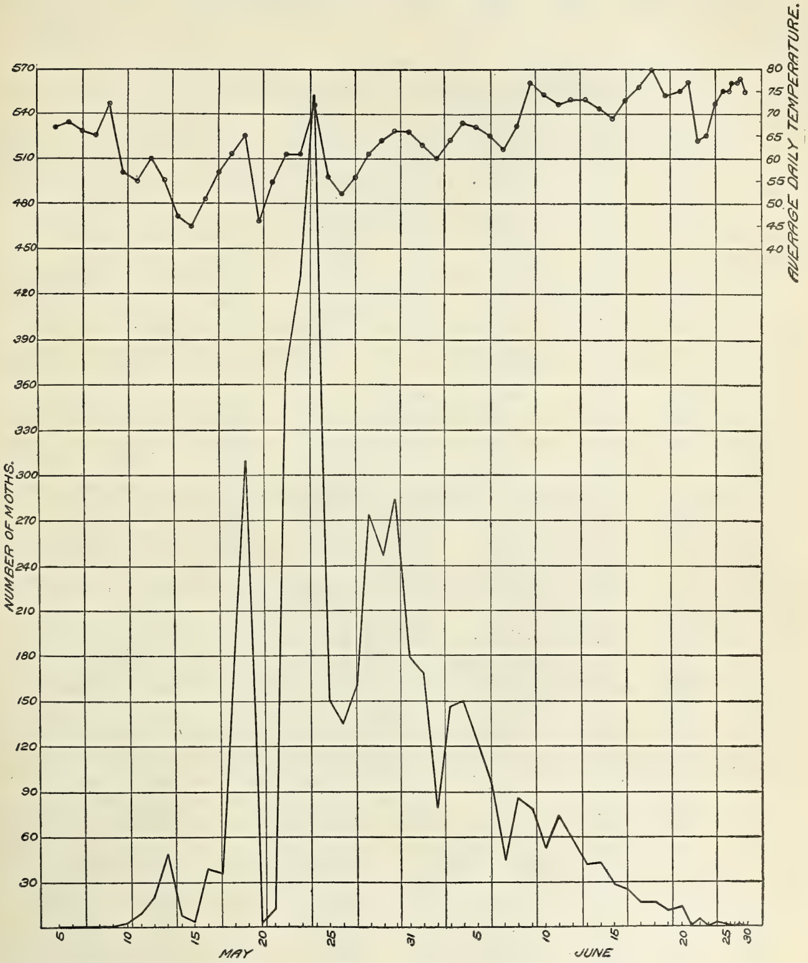


FIG. 19.—Time of emergence of codling moths of the spring brood, Grand Junction, Colo., 1916.

Number of eggs per female moth.—In connection with the oviposition studies of moths of the spring brood, it was found that the average number of eggs per female moth was 11.34.

TABLE XXXII.—*Oviposition by codling moths of the spring brood in rearing cages, Grand Junction, Colo., 1916.*

Cage No.	Number of moths.	Sex.		Date of—			Total number of eggs deposited.	Number of days—		
		Male.	Female.	Emergence of moths.	First oviposition.	Last oviposition.		Before oviposition.	Of oviposition.	From date of emergence to last oviposition.
1	20	10	10	May 13	May 21	June 4	76	8	15	22
2	5	3	2	May 14 May 15			1			
3	13	7	6	May 16	May 19	June 4	89	3	17	19
4	23	14	9	May 17	May 22	...do....	110	5	14	18
5	25	19	6	...do....	May 24	June 1	145	7	9	15
6	25	20	5	...do....	...do....	June 16	209	7	24	30
7	26	18	8	May 18	May 23	June 5	184	5	14	18
8	28	17	11	...do....	...do....	June 11	440	5	20	24
9	27	18	9	...do....	May 24	...do....	241	6	19	24
10	25	10	15	May 19	May 23	June 6	283	4	15	18
11	15	8	7	...do....	...do....	June 10	247	4	19	22
12	25	11	14	...do....	May 24	June 8	267	5	16	20
13	23	12	11	...do....	...do....	June 14	304	5	22	26
14	24	13	11	...do....	May 27	June 11	135	6	16	21
15	23	7	16	...do....	...do....	June 16	210	6	21	26
16	24	11	13	...do....	May 31	June 13	286	12	14	25
17	1	1		May 20			0			
18	2	1	1	May 21			1			
19	22	11	11	May 22	May 26	June 11	229	4	17	20
20	25	8	17	...do....	...do....	June 16	202	4	22	25
21	21	13	8	...do....	May 27	June 14	214	5	19	23
22	24	14	10	...do....	...do....	June 17	138	5	22	26
23	16	4	12	...do....	May 28	June 14	186	6	18	23
24	25	10	15	...do....	May 29	June 11	79	7	14	20
25	25	7	18	...do....	...do....	June 16	186	7	19	25
26	25	11	14	...do....	May 30	June 9	86	8	11	18
27	24	11	13	May 23	May 26	June 12	189	3	18	20
28	26	14	12	...do....	May 27	June 9	258	4	14	17
29	20	5	15	...do....	...do....	June 17	322	4	22	25
30	25	10	15	...do....	May 29	June 11	198	6	14	19
31	23	12	11	...do....	...do....	...do....	254	6	14	19
32	25	14	11	...do....	...do....	June 15	172	6	18	23
33	23	9	14	...do....	...do....	...do....	244	6	18	23
34	25	14	11	...do....	May 31	June 11	154	8	12	19
35	16	4	12	...do....	June 3	June 17	44	11	15	25
36	24	11	13	May 24	May 29	June 12	179	5	15	19
37	25	8	17	...do....	May 30	June 5	11	6	7	12
38	25	11	14	...do....	...do....	June 8	40	6	10	15
39	24	7	17	...do....	...do....	June 12	45	6	14	19
40	20	13	7	...do....	May 31	June 16	12	7	17	23
41	25	12	13	...do....	...do....	June 18	50	7	19	25
42	24	13	11	...do....	June 1	June 15	156	8	15	22
43	24	11	13	...do....	June 2	June 8	49	9	7	15
44	25	11	14	...do....	June 3	June 17	63	10	15	24
45	25	12	13	...do....	June 6	...do....	108	13	12	24
46	25	9	16	...do....	...do....	June 6	1	13	1	13
47	20	14	6	...do....			7			
48	13	6	7	...do....			14			
49	25	11	14	May 25	June 4	June 17	247	10	14	23
50	24	11	13	...do....	June 5	June 11	44	11	7	17
51	25	14	11	...do....	...do....	June 16	226	11	12	22
52	11	7	4	...do....	June 7	June 13	78	13	7	19
53	23	12	11	May 26	May 31	June 20	182	5	21	25
54	25	12	13	...do....	June 1	June 16	83	6	16	21
55	14	4	10	...do....	June 3	June 17	68	8	15	22
56	24	10	14	...do....	June 5	June 18	141	10	14	23
57	20	12	8	May 27	May 30	June 6	91	3	8	10
58	25	8	17	...do....	June 3	June 16	63	7	14	20
59	25	12	13	...do....	June 4	June 13	17	8	10	17
60	19	9	10	...do....	June 8	...do....	97	12	6	17
61	27	8	19	May 28	May 31	June 14	57	3	15	17
62	25	14	11	...do....	...do....	July 1	19	3	32	34
63	22	10	12	...do....	June 1	June 9	126	4	9	12
64	24	8	16	...do....	June 2	June 17	97	5	16	20
65	24	10	14	...do....	June 3	June 25	241	6	23	28
66	27	11	16	...do....	June 5	June 9	53	8	5	12
67	27	12	15	May 29	June 2	June 15	194	4	14	17
68	25	11	14	...do....	...do....	June 17	132	4	16	19
69	13	5	8	...do....	June 5	...do....	83	7	13	19
70	25	14	11	...do....	June 6	...do....	206	8	12	19
71	25	13	12	...do....	June 8	June 20	66	10	13	22

TABLE XXXII.—*Oviposition by codling moths of the spring brood in rearing cages, Grand Junction, Colo., 1916*—Continued.

Cage No.	Number of moths.	Sex.		Date of—			Total number of eggs deposited.	Number of days—		
		Male.	Female.	Emergence of moths.	First oviposition.	Last oviposition.		Before oviposition.	Of oviposition.	From date of emergence to last oviposition.
72	23	10	13	May 29	June 10	June 16	154	12	7	18
73	25	10	15	May 30	June 2	June 13	39	3	12	14
74	28	12	16	...do....	...do....	June 18	95	3	17	19
75	27	14	13	...do....	June 5	June 15	174	6	11	16
76	27	7	20	...do....	...do....	June 18	98	6	14	19
77	25	14	11	...do....	June 9	June 15	25	10	7	16
78	27	13	14	...do....	June 10	June 16	35	11	7	17
79	15	8	7	May 31	June 5	June 18	61	5	14	18
80	24	16	8	...do....	June 6	June 17	126	6	12	17
81	25	14	11	...do....	June 10	...do....	58	10	8	17
82	24	10	14	...do....	...do....	June 20	44	10	11	20
83	25	14	11	...do....	...do....	June 25	67	10	16	25
84	16	7	9	June 1	June 5	June 18	252	4	14	17
85	24	10	14	...do....	June 8	...do....	126	7	11	17
86	24	16	8	...do....	...do....	...do....	203	7	11	17
87	23	10	13	...do....	June 10	June 17	46	9	8	16
88	24	14	10	June 2	June 7	...do....	188	5	11	15
89	25	14	11	...do....	June 8	June 16	80	6	9	14
90	24	5	19	June 3	June 5	June 14	106	2	10	11
91	22	11	11	...do....	June 6	June 20	171	3	15	17
92	25	13	12	...do....	June 8	...do....	73	5	13	17
93	25	9	16	...do....	June 10	June 17	34	7	8	14
94	24	12	12	June 4	June 6	June 24	269	2	19	20
95	24	9	15	...do....	June 7	June 21	327	3	15	17
96	26	11	15	...do....	June 9	...do....	158	5	13	17
97	28	14	14	...do....	June 10	June 20	95	6	11	16
98	24	12	12	June 5	...do....	June 21	94	5	12	16
99	23	11	12	...do....	June 12	June 26	139	7	15	21
100	11	4	7	...do....	June 14	June 18	10	9	5	13
101	25	13	12	June 6	June 8	June 20	103	2	13	14
102	25	10	15	...do....	June 9	July 2	376	3	24	26
103	19	9	10	...do....	June 11	June 19	25	5	9	13
104	30	17	13	June 7	June 9	June 21	342	2	13	14
105	28	14	14	June 8	June 10	...do....	152	2	12	13
106	30	13	17	...do....	June 11	...do....	266	3	11	13
107	24	15	9	June 9	...do....	June 20	138	2	10	11
108	26	12	14	...do....	June 14	June 19	92	5	6	10
109	25	15	10	June 10	June 13	June 17	59	3	5	7
110	12	5	7	...do....	...do....	...do....	98	3	5	7
111	25	13	12	June 11	...do....	June 18	106	2	6	7
112	28	9	19	...do....	...do....	June 30	350	2	18	19
113	32	17	15	June 12	June 14	July 2	290	2	19	20
114	33	18	15	June 13	June 16	July 5	297	3	20	22
115	32	11	21	June 14	June 17	July 2	224	3	16	18
116	22	8	14	June 15	..do....	...do....	208	2	16	17
117	20	9	11	June 16	June 19	June 27	40	3	9	11
118	10	4	6	June 17	...do....	June 28	157	2	10	11
119	14	3	11	June 18	June 25	June 25	4	7	1	7
120	8	1	7	June 19	June 26	July 7	13	7	12	18
121	13	3	10	June 20	July 1	July 3	11	11	3	13
122	2	1	1	June 22	....	....	1	....	....	....
123	4	1	3	June 23	July 2	July 7	7	9	6	14
Average							....	6.07	13.38	18.46
Maximum							....	13	32	34
Minimum							....	2	1	7

Number of male moths	1,292
Number of female moths	1,449
Total number of moths	2,741
Total number of eggs	16,435
Average number of eggs per female moth	11.34

Length of life of moths.—As in the previous season, the dead moths were removed daily from the oviposition cages and the date of their death recorded. From these records the length of life of 2,738 moths was computed. As shown in Table XXXIII, the average length of life of 1,281 male moths was 14.67 days, maximum 35 days, minimum 1 day; the average length of life of 1,457 female moths was 15.73 days, maximum 39 days, minimum 1 day.

TABLE XXXIII.—*Length of life of male and female codling moths of the spring brood in captivity: Summary of records of 2,738 individual moths, Grand Junction, Colo., 1916.*

Male.		Female.		Male.		Female.		Male.		Female.	
Length of life.	Number of moths.	Length of life.	Number of moths.	Length of life.	Number of moths.	Length of life.	Number of moths.	Length of life.	Number of moths.	Length of life.	Number of moths.
Days.		*Days.*		*Days.*		*Days.*		*Days.*		*Days.*	
1	9	1	6	15	64	15	96	29	7	29	13
2	7	2	4	16	56	16	96	30	12	30	6
3	6	3	6	17	59	17	88	31	3	31	4
4	14	4	11	18	50	18	70	32	6	32	6
5	29	5	12	19	43	19	68	33	5	33	4
6	46	6	18	20	64	20	94	34	3	34	2
7	64	7	41	21	48	21	70	35	2	35	3
8	79	8	40	22	39	22	41	36	0	36	0
9	48	9	73	23	27	23	40	37	0	37	0
10	88	10	75	24	30	24	27	38	0	38	1
11	78	11	77	25	18	25	23	39	0	39	1
12	56	12	93	26	27	26	23				
13	86	13	98	27	10	27	14	Total..	1,281	Total..	1,457
14	84	14	99	28	14	28	14				

Average length of life of male moths, 14.67 days; female moths, 15.73 days.
Maximum length of life of male moths, 35 days; female moths, 39 days.
Minimum length of life of male moths, 1 day; female moths, 1 day.

THE FIRST GENERATION.

EGGS OF THE FIRST BROOD.

Time of egg deposition.—In Table XXXIV and figure 20 it will be observed that the first eggs of the first brood were deposited May 19, and the last July 7, the period of deposition covering about 7 weeks. The eggs laid on the latter date, however, were infertile, but the single egg deposited July 5 completed its development and hatched on July 11. The largest number of eggs laid in one day was 883 on June 9, and this date was approximately the middle of the oviposition period.

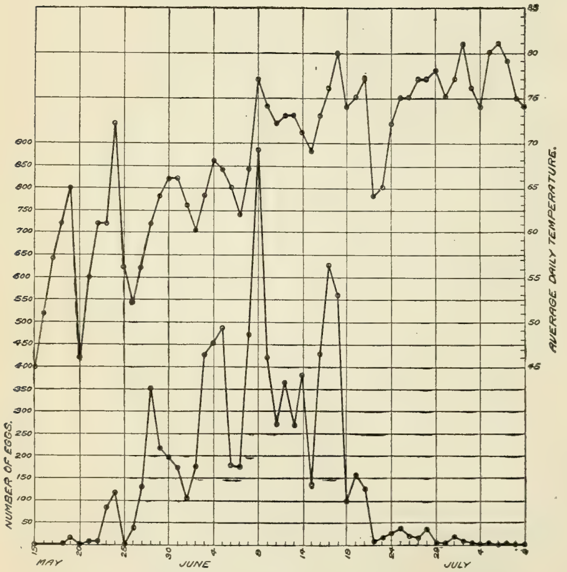


FIG. 20.—Time of deposition of eggs of the first brood of the codling moth, Grand Junction, Colo., 1916.

TABLE XXXIV.—*Time of deposition, length of incubation, and time of hatching of eggs of the first brood of the codling moth, Grand Junction, Colo., 1916.*

Observation No.	Number of eggs deposited.	Date—				Number of eggs hatched.	Appearance of—		Incubation period.
		Deposited.	Red ring.	Black spot.	Hatched.		Red ring.	Black spot.	
							Days.	*Days.*	*Days.*
1	16	May 19	May 29	May 30	June 1	14	10	11	13
2					June 2	2			14
3	7	May 21	May 24	May 30	June 1	3	3	9	11
4					June 2	4			12
5	12	May 22	May 24	May 31	...do....	7	2	9	11
6					June 3	5			12
7	86	May 23	May 25	May 31	June 2	4	2	8	10
8					June 3	24			11
9					June 4	45			12
10	117	May 24	May 28	May 30	June 3	2	4	6	10
11					June 4	60			11
12					June 5	18			12
13					June 6	2			13
14	2	May 25	May 29	June 4	June 5	2	4	10	11
15	38	May 26	...do....	...do....	...do....	28	3	9	10
16					June 6	8			11
17	130	May 27	May 29	June 5	...do....	108	2	9	8
18					June 7	12			9
19	353	May 28	May 30	June 6	...do....	304	2	9	10
20					June 8	21			11
21	218	May 29	May 31	June 7	...do....	176	2	7	8
22					June 9	20			9
23	194	May 30	June 2	June 8	...do....	173	3	9	10
24					June 10	4			11
25	177	May 31	June 3	June 9	...do....	141	3	9	10
26					June 11	2			11
27	106	June 1	June 4	June 9	June 10	70	3	8	9
28					June 11	12			10
29					June 12	2			11
30	179	June 2	June 6	June 10	June 11	143	4	8	9
31					June 12	7			10
32	425	June 3	June 6	June 10	June 11	272	3	7	8
33					June 12	55			9
34	451	June 4	June 7	June 11	...do....	307	3	7	8
35					June 13	27			9
36	486	June 5	June 8	June 12	...do....	403	3	7	8
37	180	June 6	June 9	...do....	...do....	101	3	6	7
38					June 14	40			8
39					June 15	5			9
40	176	June 7	June 9	June 13	June 14	93	2	6	7
41					June 15	23			8
42	471	June 8	June 10	June 14	...do....	320	2	6	7
43					June 16	47			8
44	883	June 9	June 11	June 15	...do....	539	2	6	7
45					June 17	247			8
46					June 18	35			9
47	420	June 10	June 11	June 16	June 17	210	1	6	7
48					June 18	63			8
49	272	June 11	June 13	June 17	...do....	239	2	6	7
50	361	June 12	June 14	June 18	June 19	245	2	6	7
51					June 20	29			8
52	267	June 13	June 15	June 19	...do....	131	2	6	7
53	380	June 14	June 17	June 20	June 21	251	3	6	7
54	136	June 15	...do....	...do....	...do....	49	2	5	6
55					June 22	31			7
56	429	June 16	June 18	June 21	...do....	9	2	5	6
57					June 23	279			7
58					June 24	30			8
59	623	June 17	June 19	June 23	...do....	355	2	6	7
60					June 25	19			8
61	558	June 18	June 20	June 24	...do....	402	2	6	7
62					June 26	22			8
63	103	June 19	June 21	June 25	...do....	37	2	6	7
64					June 27	25			8
65					June 28	3			9
66	158	June 20	June 22	June 26	June 27	46	2	6	7
67	125	June 21	June 24	June 27	June 28	31	3	6	7
68					June 29	31			8
69	8	June 22	June 25	June 28	...do....	8	3	6	7
70	16	June 23	...do....	...do....	June 30	6	2	5	7
71	29	June 24	June 26	June 29	...do....	15	2	5	6
72					July 1	4			7
73					July 2	5			8
74	37	June 25	June 27	July 1	...do....	33	2	6	8
75	21	June 26	June 28	July 2	July 3	16	2	6	8
76	16	June 27	June 30	...do....	...do....	6	3	5	7

TABLE XXXIV.—*Time of deposition, length of incubation, and time of hatching of eggs of the first brood of the codling moth, Grand Junction, Colo., 1916*—Continued.

Observation No.	Number of eggs deposited.	Date—				Number of eggs hatched.	Appearance of—		Incubation period.
		Deposited.	Red ring.	Black spot.	Hatched.		Red ring.	Black spot.	
							Days.	*Days.*	*Days.*
77	35	June 28	June 30	July 3	July 4	12	2	5	7
78	3	June 29	July 1	July 4	July 5	1	2	5	6
79	3	June 30	July 3	....	....	0	3	....	0
80	15	July 1	...do....	July 6	July 7	9	2	5	6
81	8	July 2	July 4	July 7	July 8	5	2	5	6
82	....	....	....	....	July 9	2	....	....	7
83	4	July 3	....	....	....	0	....	....	0
84	1	July 5	July 8	July 10	July 11	1	3	5	6
85	2	July 7	....	....	....	0	....	....	0
Total.	8,774	....	....	....	....	6,597	....	....	....
		Aver.				....	2.62	6.68	7.32
		Max.				....	10	11	14
		Min.				....	1	5	6

Length of incubation.—The length of incubation and embryological changes of eggs of the first brood are given in Table XXXIV as follows: Average number of days from date of deposition to the appearance of the red ring 2.62 days, maximum 10 days, minimum 1 day; average appearance of the black spot from time of deposition 6.68 days, maximum 11 days, minimum 5 days; average incubation period 7.32 days, maximum 14 days, minimum 6 days.

LARVÆ OF THE FIRST BROOD.

Time of hatching.—The time of hatching of eggs of the first brood will be found in Table XXXIV. The first eggs of this brood hatched June 1; the last, July 11. Thus the period of incubation extended over one month, the maximum number hatching on June 16, or 15 days after the first larvæ appeared. The rate of hatching is shown diagrammatically in figure 21, in which it will be noted that the majority of the larvæ hatched about the middle of the hatching period.

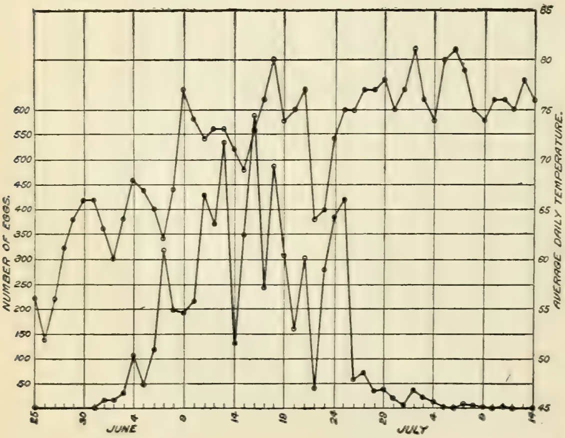


FIG. 21.—Time of hatching of eggs of the first brood of the codling moth, Grand Junction, Colo., 1916.

Length of the feeding period, stock-jar method.—The summarized account of the length of the feeding period of 817 larvæ of the first brood, stock-jar method, will be found in Table XXXV. The first larvæ, as will be noted therein, entered the fruit June 8, while the last larvæ began feeding July 10. The average length of the feeding period was 20.19 days, maximum 42 days, and minimum 14 days.

Length of the feeding period, bagged-fruit method.—In Table XXXVI is given the length of the feeding period of 264 larvæ of the first brood according to the bagged-fruit method. In this study the first larvæ entered the fruit June 1, the last June 28. Reference to the summary of the table will show that the average feeding period was 21.10 days, maximum 29 days, and minimum 17 days.

TABLE XXXV.—*Length of feeding period of larvæ of the first brood of the codling moth, stock-jar method, Grand Junction, Colo., 1916.*

Date of entering fruit.	Number of individuals.	Length of feeding period in specified days.																									
		14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	42
June 8	30	...	...	2	5	5	8	6	1	2	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
9	26	...	1	2	4	3	8	5	2	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
10	23	...	...	...	3	5	4	4	3	3	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
11	67	...	1	1	6	11	13	13	10	7	3	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
12	52	...	...	2	4	5	9	10	6	10	3	3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
13	51	...	...	...	...	7	13	11	8	5	1	3	1	1	...	...	...	...	...	...	...	...	...	...	1	...	...
14	16	...	...	...	3	3	2	4	1	2	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
15	43	...	2	9	5	4	3	5	7	1	...	4	...	...	1	1	...	...	...	...	...	...	...	...	...	...	1
16	65	...	...	1	8	7	13	15	12	3	2	1	2	...	1	...	...	...	...	...	...	...	...	...	...	...	...
17	43	...	1	2	7	7	3	11	3	4	1	...	2	1	...	...	...	...	...	...	...	1	...	...	...	...	...
18	33	...	3	4	6	3	4	4	2	...	1	2	...	2	...	...	...	...	1	...	...	...	...	...	...	1	...
19	22	...	...	...	3	6	3	1	2	2	3	...	...	...	...	1	...	1	...	...	...	...	...	...	...	...	...
20	25	...	...	1	4	3	4	6	1	...	3	...	2	...	1	...	...	...	...	...	...	...	...	...	...	...	...
21	38	...	...	3	1	4	8	5	6	4	2	...	1	2	...	...	1	1	...	...	...	...	...	...	...	...	...
22	38	1	...	3	7	5	8	7	1	3	1	1	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...
23	16	...	1	...	1	2	...	4	1	3	...	1	...	1	1	1	...	...	...	...	...	...	...	...	...	...	...
24	78	...	1	4	7	8	17	15	7	5	4	4	1	2	2	...	...	...	1	...	...	...	...	...	...	...	...
25	78	...	...	3	6	9	7	12	10	12	6	4	3	4	1	1	...	...	...	...	...	...	...	...	...	...	...
26	20	...	...	3	...	3	1	...	1	6	2	2	...	2	...	...	...	...	...	...	...	...	...	...	...	...	...
27	24	...	...	5	3	6	3	...	3	1	1	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
28	2	...	...	1	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
29	5	...	...	1	...	1	2	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
30	2	...	...	...	...	...	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
July 2	2	...	...	...	...	...	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
3	1	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
4	10	...	...	...	...	...	...	1	2	1	1	...	2	...	...	...	...	...	...	1	...	1	1	...	...	...	...
5	1	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
7	1	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
8	2	...	...	...	...	...	1	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...
10	3	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	1	...	...	1	...	...	...
	817	1	10	48	83	107	139	140	90	75	37	31	14	16	8	4	1	2	2	1	1	2	1	1	1	1	1

	Days.
Average length of feeding period	20.19
Maximum length of feeding period	42
Minimum length of feeding period	14

TABLE XXXVI.—*Length of feeding period of codling-moth larvæ of the first brood, bagged-fruit method, Grand Junction, Colo., 1916.*

Date of entering fruit.	Number of individuals.	Length of feeding period in specified days.												
		17	18	19	20	21	22	23	24	25	26	27	28	29
June 1	1	....	....	1	....	....	....	....	....	....	....	....	....	....
2	2	....	....	1	....	....	....	....	....	1	....	....	....	....
3	1	....	....	....	....	....	....	....	....	....	....	....	1	....
4	7	....	2	....	1	....	1	2	....	1	....	....	....	....
5	6	....	....	1	....	4	....	1	....	....	....	....	....	....
6	34	....	1	7	....	8	7	5	2	2	....	2	....	....
7	27	....	....	3	10	5	3	2	4	....	....	....	....	....
8	7	....	1	....	....	3	1	....	1	1	....	....	....	....
9	2	....	....	1	....	1	....	....	....	....	....	....	....	....
10	5	....	....	....	1	1	2	1	....	....	....	....	....	....
11	10	1	....	3	1	1	2	1	....	1	....	....	....	....
12	5	....	1	....	....	2	....	....	1	....	....	1	....	....
13	23	1	2	10	2	2	4	....	1	1	....	....	....	....
14	10	....	....	2	2	....	1	1	....	2	1	....	....	1
15	10	....	....	3	1	2	....	2	....	....	1	....	1	....
16	15	1	1	3	7	2	....	....	1	....	....	....	....	....
17	12	1	....	2	6	....	2	....	....	....	....	1	....	....
18	1	....	....	....	1	....	....	....	....	....	....	....	....	....
19	5	....	2	2	....	1	....	....	....	....	....	....	....	....
20	14	....	1	2	2	5	2	2	....	....	....	....	....	....
21	3	....	....	....	....	1	1	1	....	....	....	....	....	....
22	2	....	....	....	1	....	1	....	....	....	....	....	....	....
23	8	....	....	1	1	1	1	3	1	....	....	....	....	....
24	16	....	....	3	2	3	1	3	....	....	2	2	....	....
25	23	1	2	3	1	5	7	4	....	....	....	....	....	....
26	7	....	....	2	....	2	1	2	....	....	....	....	....	....
27	1	....	1	....	....	....	....	....	....	....	....	....	....	....
28	7	2	....	4	....	....	1	....	....	....	....	....	....	....
	264	7	14	54	39	49	38	30	11	9	4	6	2	1

	Days.
Average length of feeding period	21.10
Maximum length of feeding period	29
Minimum length of feeding period	17

Length of the cocooning period.—Table XXXVII gives the data for 761 larvæ, on the time which elapsed from the time each larva left the fruit until it pupated. Attention is drawn to the fact that 300, or nearly one-half, of these individuals formed their cocoons in 4 days, 195 in 5 days, and 89 in 6 days. The average cocooning period for all the larvæ was 5.53 days, the maximum 30 days, and the minimum 2 days.

TABLE XXXVII.—*Length of cocooning period, transforming codling moth larvæ of the first brood, Grand Junction, Colo., 1916.*

Larvæ left fruit.	Number of individuals.	Length of cocooning period in specified days, being the time from leaving the fruit to the time of pupation.																				Average days.	Maximum days.	Minimum days.
		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	27	30			
June 20	1	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	5.00	5	5
21	1	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	4.00	4	4
22	2	...	1	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	4.00	5	3
24	6	...	1	4	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	4.00	5	3
25	14	...	2	10	1	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	4.14	7	3
26	19	...	2	7	5	2	...	...	2	...	...	...	...	...	...	...	1	...	...	...	...	5.58	17	3
27	30	...	4	11	6	5	2	...	1	1	...	...	...	...	...	...	...	...	...	...	...	4.97	10	4
28	40	...	...	17	7	9	5	...	...	...	1	...	...	...	...	...	...	...	...	...	1	5.83	30	4
29	34	...	...	10	10	4	4	1	1	1	1	...	...	1	...	...	1	...	...	...	...	6.21	17	4
30	35	...	...	13	11	4	3	...	2	2	...	...	...	...	...	...	...	...	...	...	...	5.43	10	4
July 1	47	...	1	23	9	4	...	2	3	1	1	1	...	...	1	...	...	1	...	...	...	5.81	18	3
2	52	...	4	24	13	1	3	2	...	1	1	1	...	...	...	1	...	1	...	...	...	5.44	18	3
3	51	...	1	23	5	10	6	2	3	...	...	...	1	...	...	...	...	...	...	...	...	5.45	13	3
4	43	...	3	15	15	5	1	...	1	...	...	...	...	1	1	1	...	...	...	...	...	5.47	16	3
5	35	...	...	12	13	4	3	...	1	...	1	1	...	...	...	...	...	...	...	...	...	5.43	12	4
6	37	1	2	8	12	6	2	2	...	1	2	...	1	...	...	...	...	...	...	...	...	5.70	13	2
7	51	...	...	19	17	6	1	...	1	2	1	3	1	...	...	...	...	...	...	...	...	5.75	13	4
8	21	...	...	9	6	1	2	1	...	...	...	1	1	...	...	...	...	...	...	...	...	5.67	13	4
9	29	...	2	13	3	3	2	2	...	1	1	1	...	...	...	...	...	...	1	...	...	5.97	19	3
10	26	...	2	12	4	5	1	...	...	...	1	...	1	...	...	...	...	...	...	...	...	5.19	13	3
11	21	...	...	4	10	...	2	2	1	...	1	...	1	...	...	...	...	...	...	...	...	6.14	13	4
12	28	...	1	11	9	3	2	1	1	...	...	...	...	...	...	...	...	...	...	...	...	5.04	9	3
13	33	...	...	18	11	2	...	1	...	...	...	...	...	...	...	...	...	1	...	...	...	5.00	18	4
14	25	...	...	5	7	7	1	...	1	1	...	2	...	...	...	1	...	...	...	...	...	6.52	16	4
15	19	...	...	7	6	4	...	...	...	...	...	...	...	...	...	1	...	...	...	1	...	6.58	27	4
16	13	...	1	4	4	1	...	3	...	...	...	...	...	...	...	...	...	...	...	...	...	5.31	8	3
17	14	1	4	6	2	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	4.00	8	2
18	10	...	3	3	...	2	1	...	...	...	...	...	...	...	...	...	...	...	1	...	...	5.90	19	3
19	8	...	...	6	1	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	4.63	8	4
20	6	...	...	3	1	...	1	...	...	...	...	...	...	...	...	...	...	1	...	...	...	7.00	18	4
21	2	...	...	...	1	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	6.00	7	5
22	2	...	...	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	4.50	5	4
23	2	...	1	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	5.00	7	3
24	1	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	5.00	5	5
25	1	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	5.00	5	5
27	2	...	...	1	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	5.00	6	4
Total..	761	2	35	300	195	89	45	21	18	11	11	10	6	2	2	4	2	4	2	1	1	5.53	30	2

PUPÆ OF THE FIRST BROOD.

Time of pupation.—The larvæ of the first brood reared in the insectary began to pupate on June 25 and at this time 3 individuals transformed. The rate of pupation gradually increased until it reached its maximum on July 7, when 50 individuals pupated, as will be seen by reference to Table XXXVIII and figure 22. The last larva of this brood transformed to the pupal stage August 11. In all a total of 766 pupæ was recorded.

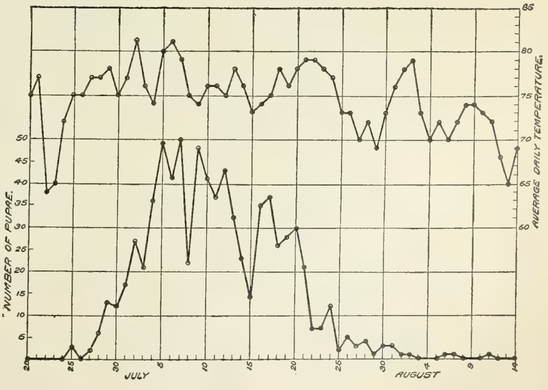


FIG. 22.—Time of pupation of first brood of the codling moth, Grand Junction, Colo., 1916.

TABLE XXXVIII.—*Time of pupation of transforming codling moth larvæ of the first brood, Grand Junction, Colo., 1916.*

Date of pupation.	Number of pupæ.	Date of pupation.	Number of pupæ.	Date of pupation.	Number of pupæ.	Date of pupation.	Number of pupæ.	Date of pupation.	Number of pupæ.
June 25	3	July 5	49	July 14	23	July 23	7	Aug. 1	1
27	2	6	41	15	14	24	12	2	1
28	6	7	50	16	35	25	2	6	1
29	13	8	22	17	37	26	5	7	1
30	12	9	48	18	26	27	3	11	1
July 1	17	10	41	19	28	28	4		
2	27	11	37	20	30	29	1	Total..	766
3	21	12	43	21	21	30	3		
4	36	13	32	22	7	31	3		

Length of the pupal stage.—The data pertaining to the length of the pupal stage of first-brood pupæ began with the individuals that transformed June 25 and ended with the larva that pupated August 6. During this interval the variations in climatic conditions were not pronounced and, as a result, the range in the pupal period is not as great as with the spring-brood pupæ, it being from a minimum of 6 to a maximum of 19 days, with an average of 11.23 days. Out of a total of 638 pupæ, 284 had a pupal period of 12 days. For further details see Table XXXIX.

TABLE XXXIX.—*Length of the pupal stage of codling moth pupæ of the first brood, Grand Junction, Colo., 1916.*

Date of pupation.	Number of individuals.	Length of the pupal stage in specified days.											
		6	8	9	10	11	12	13	14	15	16	17	19
June 25	3	....	....	....	1	....	2	....	....	....	....	....	....
27	2	....	....	....	1	1	....	....	....	....	....	....	....
28	6	....	....	....	2	4	....	....	....	....	....	....	....
29	12	....	....	....	1	7	4	....	....	....	....	....	....
30	12	....	....	....	2	9	1	....	....	....	....	....	....
July 1	17	....	....	....	....	8	8	1	....	....	....	....	....
2	26	....	....	1	2	10	9	4	....	....	....	....	....
3	20	....	1	....	2	5	9	2	....	....	1	....	....
4	35	....	1	....	2	15	15	1	1	....	....	....	....
5	46	....	....	....	2	8	22	14	....	....	....	....	....
6	39	....	....	....	1	3	21	14	....	....	....	....	....
7	49	....	....	....	....	7	17	23	2	....	....	....	....
8	22	....	....	....	....	4	7	9	1	....	1	....	....
9	47	....	....	....	2	13	22	9	1	....	....	....	....
10	39	....	....	....	1	4	20	13	1	....	....	....	....
11	36	....	....	....	1	6	20	9	....	....	....	....	....
12	42	....	....	....	1	8	21	8	3	....	....	....	1
13	30	....	....	....	....	8	7	14	1	....	....	....	....
14	21	....	....	....	2	4	11	4	....	....	....	....	....
15	13	....	....	....	3	5	4	1	....	....	....	....	....
16	34	....	....	....	3	8	15	6	2	....	....	....	....
17	37	....	....	....	1	4	13	15	4	....	....	....	....
18	25	....	....	....	1	2	9	7	6	....	....	....	....
19	26	....	....	....	....	4	7	10	5	....	....	....	....
20	29	1	....	....	....	1	5	14	8	....	....	....	....
21	21	....	....	....	....	....	7	12	2	....	....	....	....
22	7	....	....	....	....	....	1	5	1	....	....	....	....
23	7	....	....	....	....	....	1	3	2	1	....	....	....
24	12	....	....	....	....	....	2	3	4	3	....	....	....
25	2	....	....	....	....	....	....	....	1	1	....	....	....
26	4	....	....	....	....	....	....	3	1	....	....	....	....
27	3	....	....	....	....	....	1	1	1	....	....	....	....
28	4	....	....	....	....	....	....	2	1	....	....	1	....
29	1	....	....	....	....	....	1	....	....	....	....	....	....
30	3	....	....	....	....	1	1	....	....	1	....	....	....
31	3	....	....	....	....	....	1	....	2	....	....	....	....
Aug. 1	1	....	....	....	....	....	....	....	1	....	....	....	....
2	1	....	....	....	....	....	....	....	1	....	....	....	....
6	1	....	....	....	....	....	....	1	....	....	....	....	....
	638	1	2	1	31	149	284	108	52	6	2	1	1

	Days.
Average length of the pupal stage	11.23
Maximum length of pupal stage	19
Minimum length of pupal stage	6

MOTHS OF THE FIRST BROOD.

Time of emergence.—As in the studies of 1915 (p. 24), a record was kept of the time of emergence of first-brood moths reared from insectary-bred material in order to determine the approximate limits of the brood. In Table XL it will be noted that 829 moths issued from July 5 to August 19, inclusive; the same data are presented graphically with temperatures in figure 23. Records were also taken of the time of emergence of the moths that issued from the larvæ collected every three days in the Hamilton and Edwards orchards. The moths that issued up to August 13, inclusive, were used for oviposition purposes in preference to those from the insectary-bred material, because their rate of emergence corresponded more closely to that which would have occurred in the field. These data are given in Table XLI and figure 24, and, as seen therein, the first moth emerged June 25. The rate of emergence, however, was very low until July 1, but on this date 17 moths issued.

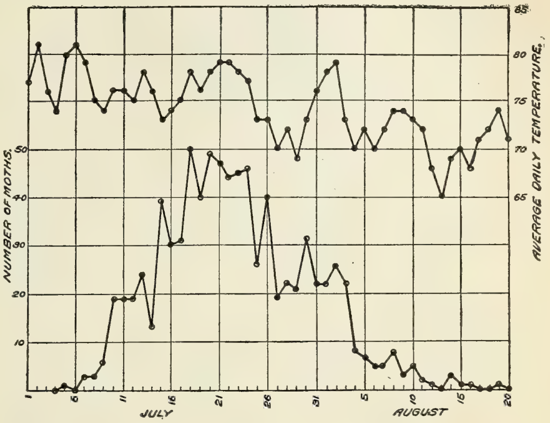


FIG. 23.—Time of emergence of codling moths of the first brood, insectary-bred material, Grand Junction, Colo., 1916.

The first moths of the second brood from insectary-bred material issued August 7, and the data indicate that from August 7 to 19 there was an overlapping of the moths of the first and second broods. Since there is no way of determining the brood to which the moths from field material belong, a date (Aug. 13) midway between that of the last emergence of the first-brood moths and the first emergence of the second-brood moths was taken as the dividing line between the two broods.

TABLE XL.—*Time of emergence of codling moths of the first brood, from material reared at the insectary, Grand Junction, Colo., 1916.*

Date of emergence.	Number of moths.	Date of emergence.	Number of moths.	Date of emergence.	Number of moths.	Date of emergence.	Number of moths.	Date of emergence.	Number of moths.
July 5	1	July 15	39	July 24	46	Aug. 2	26	Aug. 11	2
7	3	16	30	25	26	3	22	12	1
8	3	17	31	26	40	4	8	14	3
9	6	18	50	27	19	5	7	15	1
10	19	19	40	28	22	6	5	16	1
11	19	20	49	29	21	7	5	19	1
12	19	21	47	30	31	8	8		
13	24	22	44	31	22	9	3	Total...	829
14	13	23	45	Aug. 1	22	10	5		

TABLE XLI.—*Time of emergence of codling moths of the first brood reared from field material, Grand Junction, Colo., 1916.*

Date of emergence.	Number of moths.	Date of emergence.	Number of moths.	Date of emergence.	Number of moths.	Date of emergence.	Number of moths.	Date of emergence.	Number of moths.
June 25	1	July 6	25	July 17	40	July 28	165	Aug. 8	152
26	0	7	42	18	68	29	96	9	117
27	0	8	28	19	70	30	93	10	133
28	2	9	16	20	53	31	94	11	132
29	1	10	45	21	91	Aug. 1	110	12	77
30	5	11	41	22	125	2	111	13	72
July 1	17	12	72	23	76	3	95		
2	9	13	51	24	121	4	76		3,309
3	6	14	34	25	109	5	92		
4	30	15	59	26	83	6	111		
5	28	16	41	27	59	7	135		

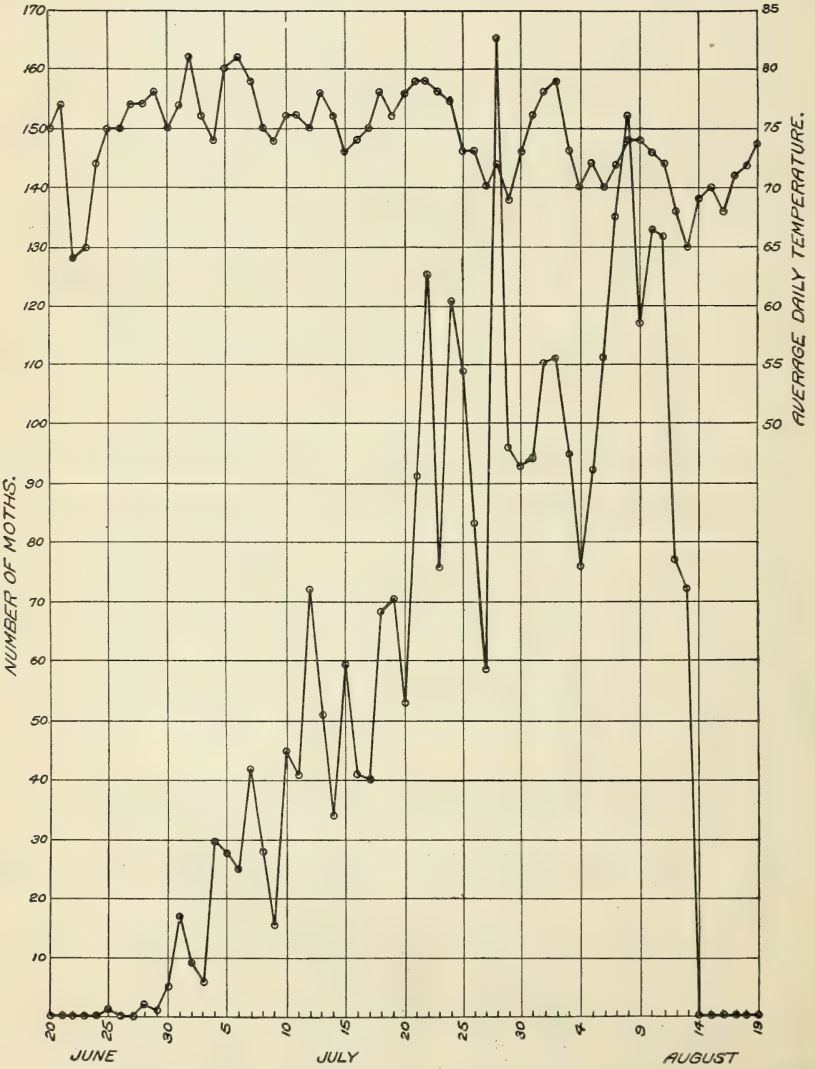


FIG. 24.—Time of emergence of codling moths of the first brood from band-collected material, Hamilton and Edwards orchards, Grand Junction, Colo., 1916.

Number of eggs per female moth.—The observations presented in Table XLII include 1,713 female moths which were confined with 1,596 male moths in 133 cages. These moths produced a total of 75,337 eggs, or an average of 43.98 eggs per female moth.

TABLE XLII.—*Oviposition by codling moths of the first brood in rearing cages, Grand Junction, Colo., 1916.*

Cage No.	Number of moths.	Sex.		Date of—			Total number of eggs deposited.	Number of days—		
		Male	Female.	Emergence of moths.	First oviposition.	Last oviposition.		Before oviposition.	Of oviposition.	From date of emergence to last oviposition.
	1			June 25						
	2			June 28						
	1			June 29						
	5			June 30						
	17			July 1						
1	26	11	15		July 3	July 15	812			
	9			July 2						
	6			July 3						
	11			July 4						
2	26	9	17		July 6	July 16	640			
3	19	10	9	July 4	...do...	July 17	315	2	12	13
4	28	14	14	July 5	...do...	July 16	322	1	11	11
5	25	6	19	July 6	July 8	...do...	753	2	9	10
6	21	13	8	July 7	...do...	July 24	398	1	17	17
7	21	14	7	...do...	July 11	July 18	134	4	8	11
8	28	14	14	July 8	...do...	July 23	541	3	13	15
9	16	4	12	July 9	...do...	July 28	256	2	18	19
10	22	8	14	July 10	...do...	July 24	161	1	14	14
11	23	15	8	...do...	July 12	July 23	479	2	12	13
12	21	9	12	July 11	...do...	July 16	125	1	5	5
13	20	15	5	...do...	July 13	July 20	219	2	8	9
14	26	14	12	July 12	...do...	July 28	352	1	16	16
15	20	9	11	...do...	July 15	July 23	516	3	9	11
16	26	10	16	...do...	...do...	July 24	204	3	10	12
17	25	12	13	July 13	July 14	July 27	612	1	14	14
18	26	13	13	...do...	July 16	July 28	357	3	13	15
19	34	17	17	July 14	July 15	July 26	1,020	1	12	12
20	33	12	21	July 15	July 17	July 30	900	2	14	15
21	26	12	14	...do...	July 21	July 27	85	6	7	12
22	26	10	16	July 16	July 17	Aug. 1	1,222	1	16	16
23	15	3	12	...do...	July 19	July 30	184	3	12	14
24	24	12	12	July 17	July 18	July 28	665	1	11	11
25	16	6	10	...do...	July 19	July 30	436	2	12	13
26	25	13	12	July 18	...do...	Aug. 1	748	1	14	14
27	25	16	9	...do...	July 20	...do...	654	2	13	14
28	18	5	13	...do...	...do...	...do...	1,088	2	13	14
29	21	11	10	July 19	...do...	July 30	555	1	11	11
30	25	10	15	...do...	July 22	July 28	420	3	7	9
31	24	14	10	...do...	...do...	July 30	579	3	9	11
32	26	12	14	July 20	...do...	July 31	794	2	10	11
33	27	8	19	...do...	July 23	July 28	341	3	6	8
34	24	7	17	July 21	July 22	July 31	281	1	10	10
35	21	5	16	...do...	...do...	Aug. 7	1,191	1	17	17
36	25	11	14	...do...	July 23	July 30	385	2	8	9
37	21	11	10	...do...	July 24	July 29	391	3	6	8
38	25	16	9	July 22	July 23	Aug. 4	791	1	13	13
39	24	14	10	...do...	July 24	Aug. 5	250	2	13	14
40	20	9	11	...do...	...do...	...do...	296	2	13	14
41	19	8	11	...do...	...do...	Aug. 7	536	2	15	16
42	24	12	12	...do...	...do...	Aug. 8	822	2	16	17
43	13	8	5	...do...	July 25	Aug. 4	228	3	11	13
44	26	14	12	July 23	July 24	Aug. 6	595	1	14	14
45	25	16	9	...do...	July 25	...do...	1,153	2	13	14
46	25	15	10	...do...	July 27	...do...	444	4	11	14
47	24	9	15	July 24	July 25	Aug. 4	1,013	1	11	11
48	25	11	14	...do...	...do...	Aug. 8	1,305	1	15	15
49	25	13	12	...do...	July 26	Aug. 9	1,017	2	15	16
50	23	8	15	...do...	...do...	Aug. 14	931	2	20	21
51	24	16	8	...do...	July 28	Aug. 4	540	4	8	11
52	28	16	12	July 25	July 27	Aug. 8	979	2	13	14
53	26	15	11	...do...	July 28	Aug. 7	802	3	11	13
54	27	11	16	...do...	...do...	...do...	1,423	3	11	13

TABLE XLII.—*Oviposition by codling moths of the first brood in rearing cages, Grand Junction, Colo., 1916*—Continued.

Cage No.	Number of moths.	Sex.		Date of—			Total number of eggs deposited.	Number of days—		
		Male	Female.	Emergence of moths.	First oviposition.	Last oviposition.		Before oviposition.	Of oviposition.	From date of emergence to last oviposition.
55	28	16	12	July 28	July 28	Aug. 8	1,065	3	12	14
56	28	18	10	July 26	...do....	...do....	709	2	12	13
67	27	14	13	...do....	...do....	...do....	1,018	2	12	13
58	28	10	18	...do....	...do....	Aug. 11	1,616	2	15	16
59	29	6	23	July 27	...do....	Aug. 15	915	1	19	19
60	30	13	17	...do....	July 29	Aug. 10	558	2	13	14
61	27	17	10	July 28	July 30	...do....	276	2	12	13
62	28	13	15	...do....	...do....	Aug. 13	381	2	15	16
63	28	20	8	...do....	July 31	Aug. 7	107	3	8	10
64	28	23	5	...do....	...do....	Aug. 8	341	3	9	11
65	28	13	15	...do....	...do....	Aug. 11	606	3	12	14
66	26	9	17	...do....	...do....	Aug. 12	1,016	3	13	15
67	24	11	13	July 29	...do....	...do....	601	2	13	14
68	22	10	12	...do....	...do....	Aug. 15	1,171	2	16	17
69	24	12	12	...do....	...do....	Aug. 16	277	2	17	18
70	26	20	6	...do....	Aug. 1	Aug. 11	432	3	11	13
71	20	13	7	July 30	July 31	...do....	408	1	12	12
72	24	15	9	...do....	Aug. 1	Aug. 14	344	2	14	15
73	24	14	10	...do....	...do....	...do....	427	2	14	15
74	25	8	17	...do....	Aug. 2	...do....	442	3	13	15
75	24	5	19	July 31	Aug. 1	Aug. 15	197	1	15	15
76	25	15	10	...do....	Aug. 2	Aug. 8	199	2	7	8
77	24	10	14	...do....	...do....	Aug. 11	468	2	10	11
78	21	9	12	...do....	Aug. 3	Aug. 12	455	3	10	12
79	28	13	15	Aug. 1	...do....	Aug. 16	565	2	14	15
80	26	15	11	...do....	...do....	Aug. 17	1,054	2	15	16
81	29	11	18	...do....	...do....	Aug. 21	991	2	19	20
82	27	12	15	...do....	...do....	...do....	1,484	2	19	20
83	29	6	23	Aug. 2	Aug. 4	Aug. 19	1,144	2	16	17
84	27	10	17	...do....	Aug. 5	Aug. 14	323	3	10	12
85	28	9	19	...do....	...do....	Aug. 19	415	3	15	17
86	27	10	17	...do....	Aug. 6	Aug. 13	562	4	8	11
87	25	11	14	Aug. 3	Aug. 5	Aug 11	608	2	4	8
88	25	14	11	...do....	...do....	Aug. 14	484	2	10	11
89	25	10	15	...do....	...do....	Aug. 16	680	2	12	13
90	20	10	10	...do....	Aug. 6	Aug. 18	373	3	13	15
91	22	5	17	Aug. 4	...do....	Aug. 17	457	2	12	13
92	22	12	10	...do....	...do....	Aug. 22	652	2	17	18
93	32	8	24	...do....	Aug. 7	Aug. 17	335	3	11	13
94	25	10	15	Aug. 5	Aug. 6	Aug. 22	1,043	1	17	17
95	25	6	19	...do....	...do....	Aug. 25	502	1	20	20
96	25	15	10	...do....	Aug. 7	...do....	468	2	19	20
97	17	15	2	...do....	Aug. 10	Aug. 10	3	5	1	5
98	26	7	19	Aug. 6	Aug. 7	Aug. 15	126	1	9	9
99	28	10	18	...do....	...do....	Aug. 17	950	1	11	11
100	28	16	12	...do....	Aug. 8	Aug. 21	575	2	14	15
101	29	10	19	...do....	...do....	Aug. 24	1,048	2	17	18
102	26	19	7	Aug. 7	...do....	Aug. 19	247	1	12	12
103	28	14	14	...do....	Aug. 9	Aug. 18	173	2	10	11
104	26	11	15	...do....	...do....	...do....	511	2	10	11
105	27	18	9	...do....	...do....	Aug. 22	479	2	14	15
106	28	12	16	...do....	Aug. 10	Aug. 24	143	3	15	17
107	27	17	10	Aug. 8	Aug. 9	Aug. 26	155	1	18	18
108	25	13	12	...do....	...do....	...do....	785	1	18	18
109	25	9	16	...do....	Aug. 10	Aug. 19	332	2	10	11
110	25	13	12	...do....	...do....	Aug. 20	234	2	11	12
111	25	16	9	...do....	...do....	Aug. 26	388	2	17	18
112	25	14	11	...do....	Aug. 11	Aug. 18	218	3	8	10
113	25	15	10	Aug. 9	Aug. 10	Aug. 23	517	1	14	14
114	25	10	15	...do....	...do....	...do....	733	1	14	14
115	25	11	14	...do....	Aug. 11	Aug. 22	710	2	12	13
116	24	9	15	...do....	...do....	Aug. 26	755	2	16	17
117	18	8	10	...do....	Aug. 14	...do....	377	5	13	17
118	27	11	16	Aug. 10	Aug. 12	Aug. 27	376	2	16	17
119	25	12	13	...do....	...do....	...do....	568	2	16	17
120	28	12	16	...do....	Aug. 14	Aug. 26	707	4	13	16
121	26	14	12	...do....	...do....	Aug. 29	624	4	16	19
122	27	14	13	...do....	...do....	Aug. 30	571	4	17	20
123	27	12	15	Aug. 11	Aug. 13	Aug. 27	703	2	15	16
124	25	13	12	...do....	...do....	Aug. 29	346	2	17	18
125	27	16	11	...do....	Aug. 14	Aug. 21	146	3	8	10
126	26	16	10	...do....	...do....	Aug. 22	445	3	9	11

Table XLII.—*Oviposition by codling moths of the first brood in rearing cages, Grand Junction, Colo., 1916*—Continued.

Cage No.	Number of moths.	Sex.		Date of—			Total number of eggs deposited.	Number of days—		
		Male.	Female.	Emergence of moths.	First oviposition.	Last oviposition.		Before oviposition.	Of oviposition.	From date of emergence to last oviposition.
127	27	14	13	Aug. 11	Aug. 14	Aug. 27	84	3	14	16
128	25	13	12	Aug. 12	...do....	Aug. 28	643	2	15	16
129	26	18	8	...do....	Aug. 15	Aug. 23	190	3	9	11
130	26	17	9	...do....	...do....	Aug. 26	406	3	12	14
131	25	17	8	Aug. 13	...do....	Aug. 29	146	2	15	16
132	25	12	13	...do....	...do....	...do....	735	2	15	16
133	22	11	11	...do....	Aug. 16	Aug. 31	609	3	16	18
Total...	3,309	1,596	1,713	....	....	....	75,337	....	....	....
Ave.								2.21	12.69	13.63
Max.								5	20	20
Min.								1	1	5

Average number of eggs per female moth, 43.98.

Time of oviposition.—As previously mentioned, the moths that issued up to August 13, inclusive, from the larvæ collected every three days from banded trees in the Hamilton and Edwards orchards, were employed for the oviposition studies.

It will be noted in the summary of this table that the average number of days from the date of emergence to the first oviposition was 2.21, maximum 5 days, minimum 1 day; the average number of days of oviposition was 12.69 days, maximum 20 days, minimum 1 day; the average number of days from the time of emergence to last oviposition was 13.63, maximum 20 days, minimum 5 days.

Length of life of moths.—A record was kept of the length of life of 3,231 moths of the first brood of which 1,561 were of the male sex and 1,670 of the female sex. According to the mortality data given in Table XLIII, the average length of life of the male moths was 13.12 days and of the female moths 12.20 days. The maximum length of life of the male moths was 38 days, female moths 26 days; minimum length of life of both the male and female moths 1 day.

TABLE XLIII.—*Length of life of male and female coaling moths of the first brood in captivity: Summary of records of 3,231 individual moths, Grand Junction, Colo., 1916.*

Male.		Female.		Male.		Female.		Male.		Female.	
Length of life.	Number of moths.	Length of life.	Number of moths.	Length of life.	Number of moths.	Length of life.	Number of moths.	Length of life.	Number of moths.	Length of life.	Number of moths.
Days.		*Days.*		*Days.*		*Days.*		*Days.*		*Days.*	
1	11	1	6	15	76	15	111	29	5	29	0
2	12	2	9	16	81	16	89	30	4	30	0
3	8	3	7	17	75	17	65	31	0	31	0
4	18	4	15	18	65	18	51	32	1	32	0
5	13	5	20	19	56	19	40	33	0	33	0
6	36	6	33	20	51	20	29	34	0	34	0
7	49	7	70	21	42	21	18	35	0	35	0
8	107	8	99	22	35	22	12	36	0	36	0
9	151	9	147	23	22	23	9	37	0	37	0
10	137	10	172	24	12	24	4	38	1	38	0
11	141	11	195	25	13	25	1				
12	124	12	156	26	5	26	1	Total..	1,561	Total..	1,670
13	102	13	169	27	4	27	0				
14	103	14	142	28	1	28	0				

Average length of life of male moths, 13.12 days; female moths, 12.20 days.
Maximum length of life of male moths, 38 days; female moths, 26 days.
Minimum length of life of male moths, 1 day; female moths, 1 day.

LIFE CYCLE OF THE FIRST GENERATION.

Life cycle, stock-jar feeding method.—The summarized data giving the average length of each stage in the life cycle of the codling moth, first generation, are given in Table XLIV. These data are derived from the observations of 550 individuals reared by the stock-jar feeding method. By reference to this table it will be found that the average length of the incubation period was 7.67 days, larval feeding period 19.33 days, cocooning period 5.61 days, and pupal period 12.26 days. The average life cycle was 44.89 days and the average complete life cycle 47.10 days, obtained by adding to the life cycle 2.21 days, which is the average time that elapsed from the emergence of the moths to the deposition of the first egg.

Life cycle, bagged-fruit feeding method.—In Table XLV the results of rearing 188 individuals of the first generation from the egg to the adult stage, bagged-fruit method, are given. By reference to this table it will be seen that the average incubation period was 8.56 days, the larval feeding period 20.45 days, cocooning period 5.26 days, pupal period 11.86 days, average life cycle 46.37 days, and the average complete life cycle 48.58 days.

TABLE XLIV.—*Life cycle of the first generation of the codling moth, as observed by rearing, stock-jar feeding method, Grand Junction, Colo., 1916.*

Date of egg deposition.	Number of individuals.	Incubation.	Larval feeding period.			Cocooning period.			Pupal period.			Life cycle.[1]		
			Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.
		Days.	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*
May 29	29	10	18. 79	23	16	6. 37	30	4	12. 03	17	8	47. 20	77	41
30	25	10	18. 80	24	15	5. 52	9	4	12. 24	16	10	46. 56	57	39
31	16	10	19. 12	22	17	4. 62	9	3	11. 87	14	10	45. 62	52	40
June 3	60	8	19. 63	24	15	6. 06	16	4	12. 18	14	10	45. 88	59	40
4	32	8	19. 93	24	16	5. 34	12	2	12. 25	13	11	45. 53	52	40
5	37	8	20. 27	26	18	5. 94	18	4	12. 62	14	11	46. 83	59	42
7	13	7	19. 46	23	17	4. 15	6	3	12. 15	13	10	42. 76	47	38
8	30	7	18. 60	27	15	5. 66	16	3	12. 23	15	11	43. 50	61	37
9	47	7	19. 55	25	16	6. 61	15	3	12. 42	14	11	45. 59	55	39
9	34	8	19. 82	34	15	6. 08	12	4	12. 29	14	10	46. 20	62	39
11	25	7	18. 16	26	15	5. 56	12	3	11. 88	15	10	42. 60	58	37
12	18	7	19. 66	30	17	5. 16	13	4	12. 33	15	10	44. 16	57	38
13	13	7	19. 38	25	17	5. 53	11	4	12. 84	19	11	44. 76	51	41
14	19	7	19. 63	29	16	4. 47	9	3	11. 94	14	10	43. 05	54	37
15	26	7	18. 57	26	14	5. 34	12	3	11. 73	14	6	42. 65	57	36
16	4	7	18. 75	22	15	4. 25	5	4	11. 25	13	10	41. 25	47	37
17	52	7	19. 44	26	15	5. 51	13	3	12. 65	15	11	44. 61	54	37
18	32	7	19. 37	28	16	6. 25	19	4	12. 40	15	10	45. 03	58	39
19	12	7	20. 66	26	16	3. 91	5	3	12. 00	13	10	43. 58	51	36
20	16	7	17. 81	22	16	4. 56	8	4	12. 25	13	11	41. 62	46	38
21	1	7	16. 00	16	16	5. 00	5	5	12. 00	12	12	40. 00	40	40
21	3	8	18. 33	20	16	3. 66	4	3	12. 66	13	12	42. 66	45	41
24	1	6	19. 00	19	19	4. 00	4	4	12. 00	12	12	41. 00	41	41
28	3	6	21. 33	23	20	5. 33	6	5	12. 33	14	11	45. 00	49	43
July 1	1	6	16. 00	16	16	3. 00	3	3	13. 00	13	13	38. 00	38	38
2	1	6	19. 00	19	19	4. 00	4	4	14. 00	14	14	43. 00	43	43
	550	7.67	19.33	34	14	5.61	30	2	12.26	19	6	44.89	77	36

[1] Add 2.21 days for complete life cycle.

TABLE XLV.—*Life cycle of the first generation of the codling moth, as observed by rearing, bagged-fruit feeding method, Grand Junction, Colo., 1916.*

Date of egg deposition.	Number of individuals.	Incubation.	Larval feeding period.			Cocooning period.			Pupal period.			Life cycle.[1]		
			Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.
		Days.	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*
May 19	1	13	19. 00	19	19	5. 00	5	5	10. 00	10	10	47. 00	47	47
22	2	11	22. 00	25	19	4. 00	4	4	11. 50	12	11	49. 50	51	46
24	6	11	20. 66	23	18	3. 66	5	3	11. 00	12	10	46. 33	50	44
26	6	10	21. 00	23	19	4. 33	5	3	11. 16	12	11	46. 50	49	44
27	28	10	21. 46	27	18	5. 25	11	3	11. 42	14	8	48. 14	58	42
28	24	10	21. 25	24	19	6. 62	18	3	12. 00	14	9	49. 87	66	44
29	7	10	21. 71	25	18	4. 71	7	3	11. 42	13	10	47. 85	52	45
30	1	10	19. 00	19	19	4. 00	4	4	12. 00	12	12	45. 00	45	45
31	5	10	21. 60	23	20	4. 20	5	4	11. 40	12	10	47. 20	50	44
June 3	9	8	20. 55	25	17	4. 44	6	4	11. 66	13	10	44. 66	49	41
4	4	8	21. 75	27	18	4. 50	5	4	12. 75	13	12	47. 00	52	44
5	22	8	20. 04	25	17	4. 95	15	3	11. 90	14	11	44. 90	57	40
7	6	7	21. 33	25	19	5. 50	8	3	12. 00	13	10	45. 83	50	42
8	6	7	19. 83	21	19	5. 00	6	4	12. 16	13	12	44. 00	46	42
9	9	7	19. 77	24	17	4. 66	7	2	11. 88	13	11	43. 33	49	39
9	8	8	19. 62	22	17	6. 50	19	4	11. 62	13	11	45. 75	62	40
12	5	7	19. 00	21	18	4. 20	5	4	12. 20	13	12	42. 40	44	41
13	7	7	20. 00	23	18	7. 00	18	4	11. 70	13	10	45. 71	60	39
14	1	7	22. 00	22	22	4. 00	4	4	13. 00	13	13	46. 00	46	46
15	1	7	20. 00	20	20	4. 00	4	4	10. 00	10	10	41. 00	41	41
16	4	7	21. 50	24	19	4. 75	6	4	12. 50	14	11	45. 75	49	41
17	4	7	20. 25	21	19	5. 00	6	4	12. 25	14	11	44. 50	47	43
18	11	7	20. 72	23	17	7. 27	19	3	12. 45	14	10	47. 45	62	38
19	3	7	21. 66	23	21	4. 66	5	4	13. 33	14	13	46. 66	48	46
20	1	7	18. 00	18	18	5. 00	5	5	12. 00	12	12	42. 00	42	42
21	7	7	18. 85	22	17	3. 57	5	2	13. 14	15	12	42. 59	49	40
	188	8. 56	20. 45	27	17	5. 26	19	2	11. 86	15	8	46. 37	66	38

[1] Add 2.21 days for complete life cycle.

THE SECOND GENERATION.

Eggs of the Second Brood.

Time of deposition.—As given in Table XLVI, eggs of the second brood were deposited from July 3 to August 31, inclusive, and during this period 46,410 eggs were laid. These data were obtained by confining the moths that emerged from the larvæ collected in the field, using all of the moths that issued up to August 13, inclusive. The greatest number of eggs laid on any one day was 2,333, and these were deposited on August 2. The time of egg deposition is shown graphically with average daily temperatures in figure 25.

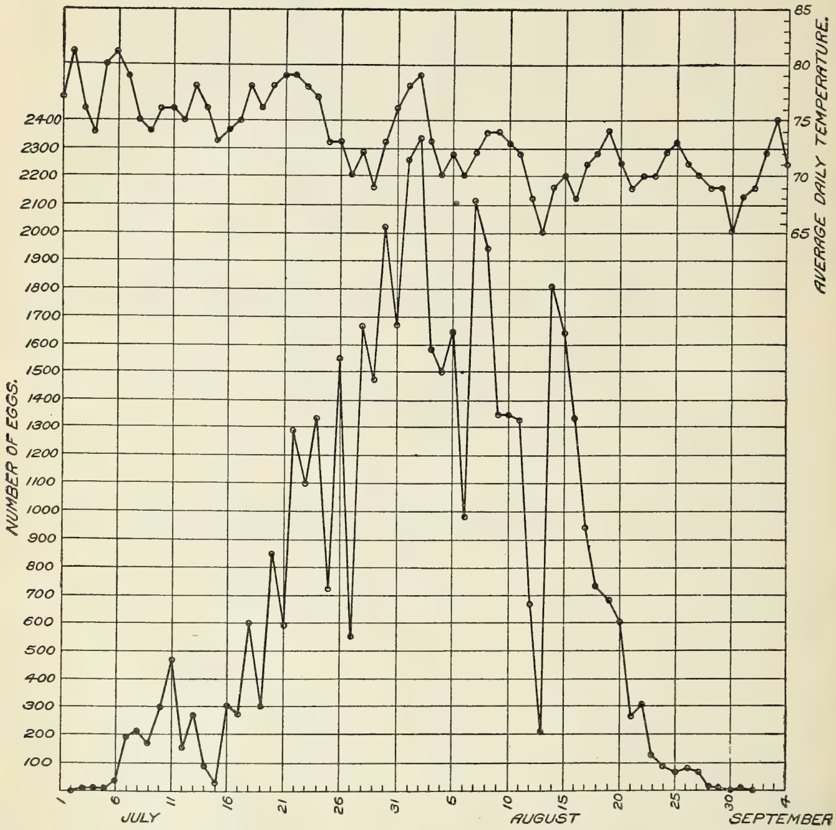


Fig. 25.—Time of deposition of eggs of the second brood of the codling moth, Grand Junction, Colo., 1916.

TABLE XLVI.—*Time of deposition, length of incubation, and time of hatching of eggs of the second brood of the codling moth, Grand Junction, Colo., 1916.*

Observation No.	Number of eggs deposited.	Date—				Number of eggs hatched.	Appearance of—		Incubation period.
		Deposited.	Red ring.	Black spot.	Hatched.		Red ring.	Black spot.	
							Days.	*Days.*	*Days.*
1	13	July 3	July 5	July 8	July 9	12	2	5	6
2	4	July 4	July 6	July 9	July 10	3	2	5	6
3	1	July 5	July 7	July 10	July 11	1	2	5	6
4	36	July 6	July 8	July 11	July 12	31	2	5	6
5	190	July 7	July 9	July 12	July 13	131	2	5	6
6	....	....	....	....	July 14	34	....	....	7
7	....	....	....	....	July 15	15	....	....	8
8	213	July 8	July 10	July 13	July 14	177	2	5	6
9	....	....	....	....	July 15	21	....	....	7
10	170	July 9	July 11	July 14	...do....	138	2	5	6
11	....	....	....	....	July 16	24	....	....	7
12	288	July 10	July 12	July 15	...do....	112	2	5	6
13	....	....	....	....	July 17	147	....	....	7
14	....	....	....	....	July 18	6	....	....	8
15	468	July 11	July 13	July 16	July 17	351	2	5	6
16	....	....	....	....	July 18	66	....	....	7
17	157	July 12	July 14	July 17	...do...	100	2	5	6
18	....	....	....	....	July 19.	24	....	....	7
19	270	July 13	July 15	July 18	...do...	116	2	5	6
20	....	....	....	....	July 20.	108	....	....	7
21	84	July 14	July 16	July 19	...do....	42	2	5	6
22	....	....	....	....	July 21	23	....	....	7
23	28	July 15	July 17	July 20	...do....	168	2	5	6
24	....	....	....	....	July 22	11	....	....	7
25	....	....	....	....	July 23	6	....	....	8
26	300	July 16	July 18	July 21	July 22	264	2	5	6
27	....	....	....	....	July 23	15	....	....	7
28	274	July 17	July 19	July 22	...do....	260	2	5	6
29	596	July 18	July 20	July 23	July 24	519	2	5	6
30	292	July 19	July 21	July 24	July 25	274	2	5	6
31	846	July 20	Juy 22	July 25	July 26	635	2	5	6
32	....	....	....	....	July 27	152	....	....	7
33	593	July 21	July 23	July 26	...do....	397	2	5	6
34	....	....	....	....	July 28	65	....	....	7
35	....	....	....	....	July 29	48	....	....	8
36	1,284	July 22	July 24	July 27	July 28	270	2	5	6
37	....	....	....	....	July 29	899	....	....	7
38	1,097	July 23	July 25	July 29	July 30	910	2	6	7
39	....	....	....	....	July 31	22	....	....	8
40	1,333	July 24	July 26	July 30	...do....	946	2	6	7
41	....	....	....	....	Aug. 1	187	....	....	8
42	722	July 25	July 27	July 31	...do....	541	2	6	7
43	....	....	....	....	Aug. 2	51	....	....	8
44	1,528	July 26	July 28	Aug. 1	...do....	1,375	2	6	7
45	....	....	....	....	Aug. 3	31	....	....	8
46	553	July 27	July 29	Aug. 2	...do....	431	2	6	7
47	....	....	....	....	Aug. 4	44	....	....	8
48	1,658	July 28	July 31	Aug. 3	...do....	1,542	3	6	7
49	1,471	July 29	...do....	...do	...do....	338	2	5	6
50	....	....	....	....	Aug. 5	941	....	....	7
51	....	....	....	....	Aug. 6	118	....	....	8
52	2,019	July 30	Aug. 1	Aug. 4	Aug. 5	727	2	5	6
53	....	....	....	....	Aug. 6	1,171	....	....	7
54	1,674	July 31	Aug. 1	Aug. 5	...do....	268	1	5	6
55	....	....	....	....	Aug. 7	1,289	....	....	7
56	2,256	Aug. 1	Aug. 3	Aug. 7	Aug. 8	2,098	2	6	7
57	2,333	Aug. 2	Aug. 4	Aug. 8	Aug. 9	1,890	2	6	7
58	1,582	Aug. 3	Aug. 6	Aug. 9	Aug. 10	1,345	3	6	7
59	1,499	Aug. 4	...do....	Aug. 10	Aug. 11	1,364	2	6	7
60	....	....	....	....	Aug. 12	30	....	....	8
61	1,641	Aug. 5	Aug. 7	Aug. 11	...do....	1,313	2	6	7
62	....	....	....	....	Aug. 13	131	....	....	8
63	....	....	....	....	Aug. 14	115	....	....	9
64	980	Aug. 6	Aug. 8	Aug. 12	Aug. 13	245	2	6	7
65	....	....	....	....	Aug. 14	696	....	....	8
66	2,115	Aug. 7	Aug. 9	Aug. 13	...do	338	2	6	7
67	....	....	....	....	Aug. 15	1,544	....	....	8
68	....	....	....	....	Aug. 16	64	....	....	9
69	1,944	Aug. 8	Aug. 10	Aug. 14	...do	1,613	2	6	8
70	....	....	....	....	Aug. 17	117	....	....	9
71	1,347	Aug. 9	Aug. 11	Aug. 14	...do	1,131	2	5	8
72	1,346	Aug. 10	Aug. 12	Aug. 17	Aug. 18	1,185	2	7	8
73	....	....	....	....	Aug. 19	67	....	....	9
74	1,322	Aug. 11	Aug. 14	Aug. 18	...do	1,190	3	7	8
75	662	Aug. 12	...do	Aug. 19	Aug. 20	549	2	7	8
76	....	....	....	....	Aug. 21	20	....	....	9

TABLE XLVI.—*Time of deposition, length of incubation, and time of hatching of eggs of the second brood of the codling moth, Grand Junction, Colo., 1916*—Continued.

Observation No.	Number of eggs deposited.	Date—				Number of eggs hatched.	Appearance of—		Incubation period.
		Deposited.	Red ring.	Black spot.	Hatched.		Red ring.	Black spot.	
							Days.	*Days.*	*Days.*
77	212	Aug. 13	Aug. 16	Aug. 19	Aug. 20	155	3	6	7
78	1,806	Aug. 14	...do....	Aug. 20	Aug. 21	307	2	6	7
79					Aug. 22	1,300			8
80					Aug. 23	72			9
81	1,641	Aug. 15	Aug. 17	Aug. 22	...do....	1,411	2	7	8
82					Aug. 24	49			9
83	1,335	Aug. 16	Aug. 18	Aug. 22	Aug. 23	147	2	6	7
84					Aug. 24	975			8
85					Aug. 25	40			9
86	943	Aug. 17	Aug. 19	Aug. 24	...do....	811	2	7	8
87	723	Aug. 18	Aug. 20	Aug. 25	Aug. 26	578	2	7	8
88	689	Aug. 19	Aug. 21	...do....	...do....	145	2	6	7
89					Aug. 27	455			8
90					Aug. 28	34			9
91	613	Aug. 20	Aug. 22	Aug. 26	Aug. 27	80	2	6	7
92					Aug. 28	447			8
93	263	Aug. 21	Aug. 23	Aug. 27	...do....	8	2	6	7
94					Aug. 29	213			8
95	306	Aug. 22	Aug. 24	Aug. 29	Aug. 30	205	2	7	8
96					Aug. 31	46			9
97	132	Aug. 23	Aug. 25	Aug. 29	...do....	111	2	6	8
98					Sept. 1	11			9
99	89	Aug. 24	Aug. 26	Aug. 31	...do....	42	2	7	8
100					Sept. 2	35			9
101					Sept. 3	3			10
102	74	Aug. 25	Aug. 27	Sept. 1	Sept. 2	46	2	7	8
103					Sept. 3	21			9
104	80	Aug. 26	Aug. 28	Sept. 2	...do....	51	2	7	8
105					Sept. 4	10			9
106	65	Aug. 27	Aug. 29	Sept. 3	...do....	52	2	7	8
107					Sept. 5	9			9
108	18	Aug. 28	Aug. 30	Sept. 4	...do....	12	2	7	8
109					Sept. 6	2			9
110	9	Aug. 29	Sept. 1	Sept. 5	...do....	7	3	7	8
111	1	Aug. 30	...do....	...do....	...do....	1	2	6	7
112	12	Aug. 31	Sept. 2	Sept. 6	Sept. 8	10	2	6	8
Total.	46,410					43,624			
		Aver.					2.06	5.80	6.93
		Max.					3	7	10
		Min.					1	5	6

Length of incubation.—As previously noted, eggs of the second brood were deposited from July 3 to August 31, inclusive, and during this period observations of the length of incubation and embryological changes of these eggs were taken. The results in detail are shown in Table XLVI. From the data obtained it was found that the appearance of the red ring averaged 2.06 days from the time of deposition, maximum 3 days, minimum 1 day; the black spot appeared on an average of 5.80 days subsequent to the time of oviposition, maximum 7 days, minimum 5 days; the average total length of the incubation period was 6.93 days, maximum 10 days, minimum 6 days.

LARVÆ OF THE SECOND BROOD.

Time of hatching.—The hatching period of larvæ of the second brood is given in Table XLVI and, as appears therein, the first of these hatched July 9, while the last hatched September 8. In connection with the control of the codling moth, the time of hatching of the second brood of eggs is of great importance, as is also the time when these eggs are hatching in largest numbers. It will be noted in this table and in figure 26 that the larvæ were appearing in greatest numbers during the middle of the hatching period. The maximum number of eggs, 2,098, hatched on August 8.

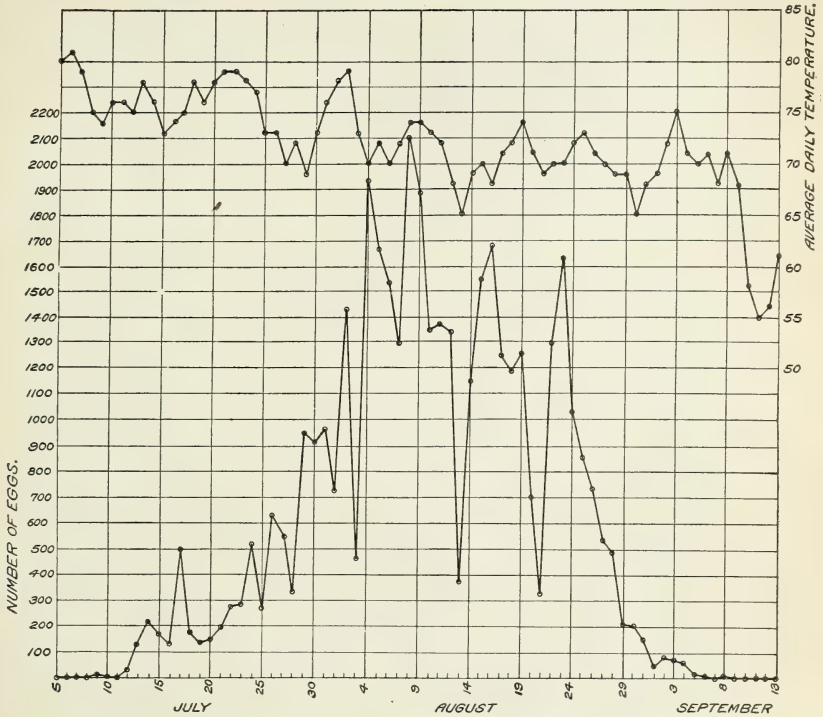


FIG. 26.—Time of hatching of eggs of the second brood of the codling moth, Grand Junction, Colo., 1916.

Length of the feeding period.—The data on the length of the feeding period of larvæ of the second brood, stock-jar method, are presented in detail in Table XLVII. The records are given for 2,569 larvæ, the dates of the entrance of which into the fruit and of leaving the fruit were observed. The summarized computations show that the average length of the feeding period of these larvæ was 28.61 days, maximum 70 days, minimum 14 days.

TABLE XLVII.—*Length of feeding period of codling moth larvæ of the second brood, stock-jar method, Grand Junction, Colo., 1916.*

Date of entering fruit.	Number of individuals.	Length of feeding period in specified days.																										
		14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
July 9	40	2	8	3	13	6	4	1			1			1	1													
10	45	1	3	6	8	4	6	5	5	4	1				1	1												
11	51		2	3	7	7	1	8	4	9	4	2		2		1												
12	91	2	3	6	6	7	15	5	8	5	7	6	6	1	2	1	3	2	1		1	1		1	1	1		
13	71		2	1	3	3	11	11	5	6	5	7	2	4	3	1	3	1	1				1		1			
14	74		1	2	1	3	15	9	8	6	4	1	7	6		2	2	3	1			1				1		1
15	51		1	1		2	3	6	3	9	6	6	2	3		1	1	4	1	1						1		
16	76			2	2	3	1	12	8	11	6	5	5	3	5	2	5	1			1			2	1			
17	102				1	5	7	11	11	13	14	13	6	4	2	2	2	1	2	2		1	1		4			
18	83				2	1	6	7	6	15	7	8	10	4	1	1	2	3	2	1	1	1	1		1		1	
19	92					2	3	15	13	13	15	12	2	3	5	1	2	1	3	1				1				
20	56					3	3	5	8	7	4	4	3	1	2	3	2	3	2	1				1			1	
21	59				1		4	6	6	7	2	8	4	3	1	4	1	2		3		1						
22	77						2	8	7	7	7	16	5	5	7	2	1		2	1			1	2	1			
23	59						1	4	4	1	6	1	8	7	3	5		1	5		2	3			2	1	1	1
24	72						1	2	2	6	8	10	8	6	1	4	3	3	3	1	4	1	1		2		2	1
25	53							1	1	2	10	7	7	6	3	1	2		6	1		1	1			1		
26	79						1	3	1	6	8	14	3	12	7	5	5		2	2	2	1	3	1		1		
27	59						1	1	2	2	8	7	2	6	7	4	5	3	1	3	2	2	1	1				
28	37							1	1		4	9	5	3	3	1	3		3		1					1		
29	39									1	5	4	2	4	1	2	3	3	1	1	1		2	3		1		
30	48								5	3	6	4	6	2	2	2	4	1	1	1	3	2				1		1
31	47						1		2	4	1	2	5	4	5	4	1	5	3	3	2	2		1				
Aug. 1	34								1	1	2	2	4	6	2	2	2	1	5	1			1		2			1
2	46							1	1		3	4	6	5	7	4			1	3	1		1	1				1
3	41								1	3	2	7	7	3	3	4	3	4			2							
4	56							1		2	6	7	5	3	1	4	7	1	3	1	1	1	1	2	1	2		
5	43									2	2	3	1	3	5	4	6	3	4	1	1	1		1		1	1	2
6	46							1		2	1	4	6	2	3	4	4	4	1	1		1	2	2	1	4	1	
7	41									4		4	3	4	4	7	5		4	2	1		1			1		
8	44							1			1	3	7	5	1	5	2	6	3	1	1	2			2		1	
9	40											2	5	4	1	5	4	3	1	1	1	1	1	2	1		1	
10	30										2	1	5	2	1	1		3	1	1	1	1	3	2	1	2	1	
11	33										3	2	2	1	6		2	2			4	1	2		2	1		1
12	30									1	3	6	3	5		2	1	1	1			1				1		1
13	13							1		1	1	1		3			1	2	1	1						1		
14	12								1	1	1		1		1		1	2		2								
15	41							2	3	3	4	6	5	3		4	2		2		1	2	1			1	1	
16	29								1	3	3	5		2	1		3	1	1	1	1	1						
17	18								2	1	3	1	1	1	2	2			1				2		1		1	
18	28										1	1	2	2	2	1		4	1		1		3		1	1	1	
19	21										2					3	4	1	1	1	1	2		1			1	
20	29										2		1	1	2	3	1	2	4		4		1	1	2			
21	16											2			2	2	3	2	1	1			1					
22	18											1		1			1	2		1	1	2	2	1		1		
23	16											1				1	1	3	2		2			1		1		
24	31														1	1		1	1	1	3		1	2	2	1	2	1
25	30												1		1		1	1	3	4	1		2	2		1		1
26	27											1	2	1			2	3	1	1	1	2	1		1	1		1
27	32									1		1		1		1	3	3	4	2		2	2	1	1	2	1	
28	25														1			1	1	1	4	1	2			1	1	3
29	21												1	1	1		1		3	3	1	1		2	1	1		
30	14														1						1	1		2		2		
31	39													1		2	2	2	6	6		3	2	2	2	2	3	1
Sept. 1	46													1				3	5	1	2	2	5	2	1	2	4	1
2	46														1	1		4		1	2	1	1	2	2	2	5	
3	25														1	1	3				1	1		1			1	
4	14																	1		1	1		1	1		1	1	1
5	11																			2				2		2		
6	12																		1		1				1			
8	10																						1		1			
		5	20	24	44	46	86	128	120	162	181	211	166	151	113	114	115	103	103	64	62	47	52	46	39	44	32	19

TABLE XLVII.—*Length of feeding period of codling moth larvæ of the second brood, stock-jar method, Grand Junction, Colo., 1916*—Continued.

Date of entering fruit.	Number of individuals.	Length of feeding period in specified days.																												
		41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	70
July 11	51				1																									
16	76		1																											
18	83	1	1																											
20	56		1									1							1		1									
21	59					1											1			1				1			1			
22	77									1						1									1					
23	59			1		1																							1	
24	72						1											1								1				
25	53			1										1				1												
26	79											1												1						
27	59																					1								
28	37	1								1																				
29	39		2	1							1								1											
30	48	1			1	1														1										
31	47			1			1																							
Aug. 1	34	1																												
2	46		1	2		1				1	1									1										
3	41					1																						1		
4	56	2		1	2	1		1																						
5	43		1		1																									
6	46								1																1					
7	41		1																											
8	44	2			1																									
9	40	1		3						1					1							1								
10	30	1										1		1																
11	33	1			1			1					1																	
12	30	1							1				1									1								
14	12						1														1									
15	41														1															
16	29	1		1			2	1					1																	
18	28			1	3	1				1			1																	
19	21		1	1				2																						
20	29		1	2		1													1											
21	16						1	1																						
22	18	1					1			1						2														
23	16		2			1					1																			
24	31	1	2	2	2				1				2		1					1				2						
25	30	3	2	1	1		2							1									1		1					
26	27	2				2					1	1						2											1	
27	32	1	2		1							1		1						1										
28	25	1		3		1										3								1						
29	21		1	1										1	1								1							
30	14	1			1			1					1	3																
31	39		1					2				1	1																	
Sept. 1	46				2	1	2	2			1	4						2		2						1				
2	46	2	2		5	3					1						1	2	1			3	3	1						
3	25		2	2						2		1	1	1	1	1				1	1		1	1						1
4	14			1					1							1	1			1			1							
5	11							1				1		1						1	1									
6	12	1	1				3						1			1			1	1										
8	10			1					2		2				1	1			1											
	2,569	36	25	26	22	16	14	12	6	8	8	11	10	10	6	10	3	8	6	11	4	6	7	7	3	2	1	1	2	1

	Days.
Average length of feeding period	28.61
Maximum length of feeding period	70
Minimun length of feeding period	14

Length of cocooning period.—The data on the length of time consumed in constructing the cocoon by the transforming larvæ of the second brood are presented in Table XLVIII. By reference to this table it will be seen that the average cocooning period of 171 individuals was 4.80 days, the maximum 14, and the minimum 2 days.

TABLE XLVIII.—*Length of cocooning period of transforming codling moth larvæ of the second brood, Grand Junction, Colo., 1916.*

Larvæ left fruit.	Number of individuals.	Length of cocooning period in specified days, being the time from leaving the fruit to the time of pupation.											Ave.	Max.	Min.
		2	3	4	5	6	7	8	9	10	12	14			
													Days.	*Days.*	*Days.*
July 23	2	....	....	2	....	....	....	....	....	....	....	....	4.00	4	4
24	8	....	....	4	2	2	....	....	....	....	....	....	4.75	6	4
25	6	....	....	1	5	....	....	....	....	....	....	....	4.83	5	4
26	15	....	....	5	8	2	....	....	....	....	....	....	4.80	6	4
27	18	....	....	8	9	1	....	....	....	....	....	....	4.61	6	4
28	15	....	2	9	3	....	1	....	....	....	....	....	4.27	7	3
29	13	....	3	8	2	....	....	....	....	....	....	....	3.92	5	3
30	12	....	7	2	3	....	....	....	....	....	....	....	3.67	5	3
31	19	....	2	5	7	3	2	....	....	....	....	....	4.89	7	3
Aug. 1	10	....	1	5	2	2	....	....	....	....	....	....	4.50	6	3
2	17	....	....	5	5	5	1	....	....	....	....	1	5.65	14	4
3	8	....	....	4	1	2	....	1	....	....	....	....	5.13	8	4
4	6	....	....	4	2	....	....	....	....	....	....	....	4.33	5	4
5	7	1	....	2	3	1	....	....	....	....	....	....	4.43	6	2
6	3	....	....	1	2	....	....	....	....	....	....	....	4.67	5	4
7	2	....	....	2	....	....	....	....	....	....	....	....	4.00	4	4
8	4	....	....	....	1	1	1	....	....	....	1	....	7.50	12	5
9	1	....	....	....	....	1	....	....	....	....	....	....	6.00	6	6
10	1	....	....	....	....	....	....	....	....	1	....	....	10.00	10	10
11	1	....	....	....	....	....	....	....	1	....	....	....	9.00	9	9
13	2	....	....	....	....	....	1	....	....	1	....	....	8.50	10	7
14	1	....	....	....	1	....	....	....	....	....	....	....	5.00	5	5
Total...	171	1	15	67	56	20	6	1	1	2	1	1	4.80	14	2

PUPÆ OF THE SECOND BROOD.

Time of pupation.—The insectary reared larvæ of the second brood began pupating July 27, when 2 individuals transformed. The number of larvæ transforming daily increased up to August 1 and, as will be seen in Table XLIX and figure 27, 23 individuals pupated on this date. The last pupation occurred August 23.

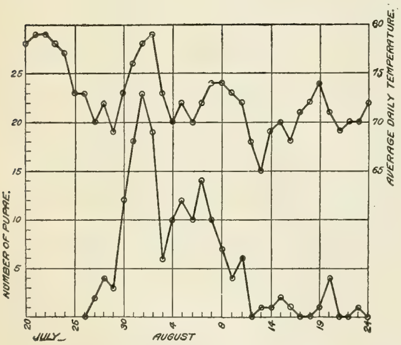


FIG. 27.—Time of pupation of second brood of the codling moth, Grand Junction, Colo., 1916.

Length of the pupal stage.—Data on the length of the pupal stage of 160 pupæ of the second brood were obtained. These observations are recorded in Table L, and, as shown therein, the observations included pupæ that transformed from July 27 to August 23. Owing to the fairly even climatic conditions during this period there was little difference in the length of the pupal stage, the range being from 11 to 16 days, with an average of 13.51 days.

TABLE XLIX.—*Time of pupation of transforming codling moth larvæ of the second brood, Grand Junction, Colo., 1916.*

Date of pupation.	Number of pupæ.	Date of pupation.	Number of pupæ.	Date of pupation.	Number of pupæ.	Date of pupation.	Number of pupæ.	Date of pupation.	Number of pupæ.
July 27	2	Aug. 2	19	Aug. 8	10	Aug. 14	1	Aug. 20	4
28	4	3	6	9	7	15	2	21	0
29	3	4	10	10	4	16	1	22	0
30	12	5	12	11	6	17	0	23	1
31	18	6	10	12	0	18	0		
Aug. 1	23	7	14	13	1	19	1	Total....	171

TABLE L.—*Length of the pupal stage of codling moth pupæ of the second brood, Grand Junction, Colo., 1916.*

Date of pupation.	Number of individuals.	Length of the pupal stage in specified days.						Date of pupation.	Number of individuals.	Length of the pupal stage in specified days.					
		11	12	13	14	15	16			11	12	13	14	15	16
July 27	1	1	....	....	....	....	....	Aug. 9	7	....	....	3	2	2	....
28	3	....	1	2	....	....	....	10	4	....	....	....	4	....	....
29	3	1	2	....	....	....	....	11	6	....	....	....	4	2	....
30	12	1	9	2	....	....	....	13	1	....	....	....	1	....	....
31	17	1	1	6	8	1	....	14	1	....	....	....	1	....	....
Aug. 1	21	1	2	10	6	1	1	15	2	....	1	....	....	....	1
2	17	....	....	7	3	6	1	16	1	....	....	1	....	....	....
3	6	....	....	2	4	....	....	19	1	....	....	....	1	....	....
4	9	....	....	4	4	1	....	20	3	....	....	1	1	1	....
5	12	....	1	5	4	2	....	23	1	....	....	....	1	....	....
6	9	....	1	5	3	....	....								
7	13	....	....	3	9	1	....	Pupæ...	160	5	19	52	60	20	4
8	10	....	1	1	4	3	1								

	Days.
Average length of pupal stage	13.51
Maximum length of pupal stage	16
Minimum length of pupal stage	11

MOTHS OF THE SECOND BROOD.

Time of emergence.—The time of emergence of 170 moths of the second brood is presented in Table LI. The first of these moths issued August 7, the last about one month later on September 6. The period of greatest emergence occurred from August 14 to August 21. As has already been referred to (p. 59), there is an overlapping of moths of the first and second broods from August 7, the time when the first moths of the second brood appeared, to August 19, when the last of the first brood of moths emerged. In figure 28 will be found a graph illustrating the time of emergence with average daily temperatures.

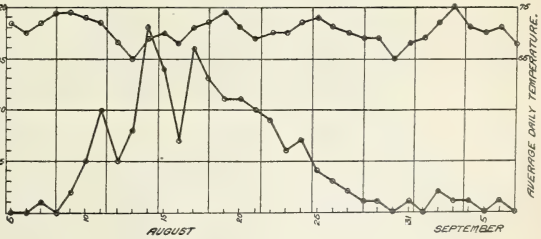


FIG. 28.—Time of emergence of codling moths of the second brood, Grand Junction, Colo., 1916.

TABLE LI.—*Time of emergence of codling moths of the second brood, from material reared at the insectary, Grand Junction, Colo., 1916.*

Date of emergence.	Number of moths.	Date of emergence.	Number of moths.	Date of emergence.	Number of moths.	Date of emergence.	Number of moths.	Date of emergence.	Number of moths.
Aug. 7	1	Aug. 14	18	Aug. 20	11	Aug. 26	3	Sept. 3	1
9	2	15	14	21	10	27	2	4	1
10	5	16	7	22	9	28	1	6	1
11	10	17	16	23	6	29	1		
12	5	18	13	24	7	31	1	Total..	170
13	8	19	11	25	4	Sept. 2	2		

Number of eggs per female moth.—Included in this study were 86 female moths which were confined with 78 males in four cages. As will be noted in Table LII, 3,920 eggs were deposited, or 45.58 eggs per female moth.

Time of oviposition.—Since only a comparatively small number of moths of the second brood emerged each day, the maximum never exceeding 16, it was thought best, for purposes of uniform manipulation, to confine moths of several days' emergence in the same cage, as shown in Table LII. It was therefore impossible to obtain accurately the length of life of these moths and the period before, of, and after oviposition. It will be noted, however, by reference to this table and Table LIV, that the first oviposition by these moths occurred August 12, three days after the first female moth emerged. The last female died September 28, 7 days after the last egg was deposited.

TABLE LII.—*Oviposition by codling moths of the second brood in rearing cages, Grand Junction, Colo., 1916.*

Cage No.	Number of moths.	Date of emergence of moths.	Sex of moths.		Total number of eggs deposited.	Cage No.	Number of moths.	Date of emergence of moths.	Sex of moths.		Total number of eggs deposited.
			Male.	Female.					Male.	Female.	
1	1	Aug. 7	20	25	1,631	4	9	Aug. 22	21	18	571
	2	Aug. 9					6	Aug. 23			
	5	Aug. 10					7	Aug. 24			
	9	Aug. 11					4	Aug. 25			
	5	Aug. 12					3	Aug. 26			
	7	Aug. 13					2	Aug. 27			
	16	Aug. 14					1	Aug. 28			
2	14	Aug. 15	26	23	1,627		1	Aug. 29			
	6	Aug. 16					1	Aug. 31			
	16	Aug. 17					2	Sept. 2			
	13	Aug. 18					1	Sept. 3			
3	11	Aug. 19	11	20	91		1	Sept. 4			
	10	Aug. 20					1	Sept. 6			
	10	Aug. 21									
						Total...	164	....	78	86	3,920

Average number of eggs per female, 45.58.

Length of life of moths.—As noted in the preceding paragraph, it was impossible to obtain accurate data on the length of life of the moths of the second brood, since the moths of several days' emergence were confined in the same cage. However, one moth, a male, lived until September 30, 24 days after the last moth emerged. The last female died September 28, 22 days after the last moth emerged.

Life Cycle of the Second Generation.

The data on the life cycle of the second generation, as given in Table LIII, include 161 individuals. The summary of the records gives an average for the incubation period of 6.01 days, larval feeding period 18.08 days, cocooning period 4.78 days, pupal period 13.52 days, and life cycle 42.40 days. To determine the length of the complete life cycle of this generation for 1916, approximately 3 days should be added to these figures, since as noted in a previous paragraph headed "Time of oviposition," 3 days elapsed between the date of emergence of the first female moth and the date the first egg was deposited.

Table LIII.—*Life cycle of the second generation of the codling moth, as observed by rearing, stock-jar feeding method, Grand Junction, Colo., 1916.*

Date of egg deposition.	Number of individuals.	Incubation.	Larval feeding period.			Cocooning period.			Pupal period.			Life cycle.		
			Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.
		Days.	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*
July 3	22	6	16.45	19	14	5.00	7	4	13.04	15	11	40.50	46	35
4	20	6	17.00	21	14	4.60	6	3	13.25	16	11	40.85	46	36
5	24	6	19.00	24	15	4.79	6	4	14.12	16	12	43.91	50	37
6	34	6	17.85	25	14	4.35	7	3	13.38	16	11	41.58	51	36
7	12	6	18.16	23	15	4.58	6	3	13.50	15	12	42.25	49	36
8	17	6	18.64	21	15	4.64	8	3	13.29	15	12	42.58	48	36
9	7	6	18.00	21	15	5.85	14	3	13.57	14	13	43.42	51	37
10	9	6	18.44	20	16	4.00	5	2	13.77	15	13	42.22	45	39
11	5	6	20.20	22	18	5.20	7	4	13.40	14	12	44.80	47	41
12	3	6	19.66	23	17	6.00	10	4	14.33	15	14	46.00	54	41
13	1	6	20.00	20	20	6.00	6	6	14.00	14	14	46.00	46	46
13	2	7	21.00	24	18	5.50	7	4	13.50	14	13	47.00	51	43
15	2	6	18.00	19	17	5.00	6	4	15.50	16	15	44.50	47	42
16	2	6	21.00	22	20	9.50	10	9	14.00	14	14	50.50	52	49
20	1	6	19.00	19	19	5.00	5	5	14.00	14	14	44.00	44	44
	161	6.01	18.08	25	14	4.78	14	2	13.52	16	11	42.40	54	35

THE THIRD GENERATION.

Eggs of the Third Brood.

Time of deposition.—The moths of the second brood commenced to deposit third-brood eggs on August 12 and on September 10 laid the last egg that fully developed. One egg was laid much later, September 21, but this failed to reach maturity. The largest number of eggs laid in any one day, 223, was deposited on August 27. For further details of the time of oviposition see Table LIV and figure 29.

Table LIV.—*Time of deposition, length of incubation, and time of hatching of eggs of the third brood of the codling moth, Grand Junction, Colo., 1916.*

Observation No.	Number of eggs.	Date—				Appearance of—		Incubation period.
		Deposited.	Red ring.	Black spot.	Hatched.	Red ring.	Black spot.	
						Days.	*Days.*	*Days.*
1	49	Aug. 12	Aug. 17	Aug. 19	Aug. 20	5	7	8
2	2	...do...			Aug. 21			9
3	3	Aug. 13	Aug. 15	Aug. 19	Aug. 20	2	6	7
4	31	...do...			Aug. 21			8
5	15	Aug. 14	Aug. 16	Aug. 20	...do...	2	6	7
6	138	...do...			Aug. 22			8
7	26	Aug. 15	Aug. 17	Aug. 21	...do...	2	6	7
8	117	...do...			Aug. 23			8
9	21	Aug. 16	Aug. 18	Aug. 22	...do...	2	6	7
10	82	...do...			Aug. 24			8
11	3	...do...			Aug. 25			9
12	34	Aug. 17	Aug. 19	Aug. 23	Aug. 24	2	6	7
13	6	...do...			Aug. 25			8
14	2	...do...			Aug. 26			9
15	89	Aug. 18	Aug. 20	Aug. 24	Aug. 25	2	6	7
16	68	...do...			Aug. 26			8
17	79	Aug. 19	Aug. 21	Aug. 25	...do...	2	6	7
18	77	...do...			Aug. 27			8
19	98	Aug. 20	Aug. 22	Aug. 26	...do...	2	6	7
20	82	...do...			Aug. 28			8
21	80	Aug. 21	Aug. 23	Aug. 27	...do...	2	6	7
22	16	...do...			Aug. 29			8
23	63	Aug. 22	Aug. 24	Aug. 28	...do...	2	6	7
24	27	...do...			Aug. 30			8
25	84	Aug. 23	Aug. 25	Aug. 29	Aug. 31	2	6	8
26	15	...do...			Sept. 1			9
27	68	Aug. 24	Aug. 26	Aug. 31	...do...	2	7	8
28	5	Aug. 25	Aug. 27	...do...	...do...	2	6	7
29	129	...do...			Sept. 2			8
30	16	...do...			Sept. 3			9
31	107	Aug. 26	Aug. 28	Sept. 2	...do...	2	7	8
32	7	...do...			Sept. 4			9
33	150	Aug. 27	Aug. 31	Sept. 3	...do...	4	7	8
34	71	...do...			Sept. 5			9
35	2	...do...			Sept. 6			10
36	31	Aug. 28	Aug. 31	Sept. 3	Sept. 4	3	6	7
37	2	...do...			Sept. 5			8
38	2	Aug. 29	Sept. 1	Sept. 4	...do...	3	6	7
39	51	...do...			Sept. 6			8
40	20	Aug. 30	Sept. 2	Sept. 5	...do...	3	6	7
41	7	...do...			Sept. 7			8
42	7	Aug. 31	Sept. 3	Sept. 6	...do...	3	6	7
43	11	...do...			Sept. 8			8
44	3	...do...			Sept. 10			10
45	3	Sept. 1	Sept. 4	Sept. 7	Sept. 8	3	6	7
46	5	...do...			Sept. 9			8
47	1	Sept. 3		Sept. 10	Sept. 11		7	8
48	1	...do...			Sept. 12			9
49	1	Sept. 4		Sept. 12	Sept. 14		8	10
50	*5	Sept. 5						
51	*1	Sept. 7						
52	1	Sept. 10	Sept. 12	Sept. 19	Sept. 21	2	9	11
53	*1	Sept. 21						
Av.						2.49	6.36	7.77
Max						5	9	11
Min						2	6	7

* Eggs not included in averages, due to failure to develop fully.

Length of incubation.—The tabulated data of the embryological changes and length of the incubation of eggs of the third brood are given in Table LIV. From these data it was found that the average number of days from the date of deposition to the appearance of the red ring was 2.49 days, maximum 5 days, and minimum 2 days; the average number of days from the time of deposition to the appearance of the black spot was 6.36 days, maximum 9 days, and minimum 6 days; the average incubation period was 7.77 days, maximum 11 days, and minimum 7 days.

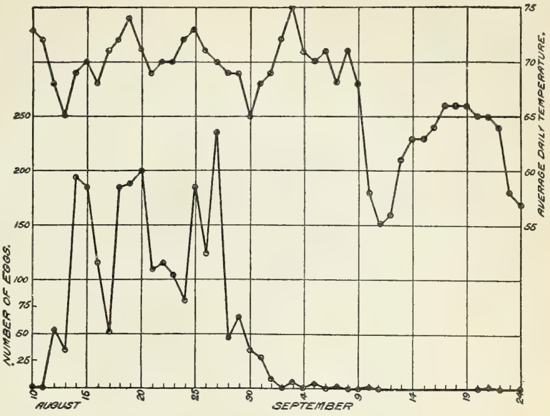


FIG. 29.—Time of deposition of third-brood eggs of the codling moth, Grand Junction, Colo., 1916.

LARVÆ OF THE THIRD BROOD.

Time of hatching.—The larvæ of the third brood commenced to hatch August 20, as will be noted in Table LIV and figure 30. Hatching continued daily, with some exceptions, up to September 21, the period thus having a duration of about one month. The larvæ were hatching in maximum numbers on September 4, and on this date 188 hatched. A large proportion of the eggs, however, hatched previous to this, namely from August 22 to 29.

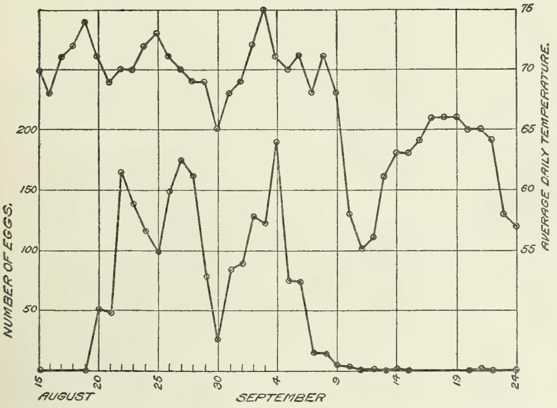


FIG. 30.—Time of hatching of third-brood eggs of the codling moth, Grand Junction, Colo., 1916.

Length of the feeding period.—The study of the feeding period of larvæ of the third brood, stock-jar method, included 331 larvæ. The first larvæ to hatch entered the fruit August 20, while the last larvæ entered the fruit September 21. None of the larvæ that entered the fruit after September 11 reached maturity. It will be noted in Table LV that the average feeding period of the larvæ under observation was 37.55 days, maximum 68 days, and minimum 20 days.

TABLE LV.—*Length of feeding period of codling moth larvæ of the third brood, stock-jar method, Grand Junction, Colo., 1916.*

Date of entering fruit.	Number of individuals.	Length of feeding period in specified days.																			
		20	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Aug. 20	27	3	1						3	1		7		1		1	2	1	2	1	
21	16		1	2	2	3		1	1		3		1			1					
22	23		1		2	1		1		5	1	1			1					2	
23	16								3	1	2		1	1	2			1			2
24	9							2	1	2			3								
25	17						1	2	1	1		2	1	2	1	1			3		
26	23			1			1				1		1	1			3	3			1
27	19						2		1	1		2	1	1		1	3				1
28	16									1	2	1				2	1		1	2	
29	18					1				2		2		1	1	1	4		1	1	
30	13												1	1			2	2			
31	29						2				1	1	4		2	3	1	1	3	4	1
Sept. 1	23							1			1	1	1	1	1	5	1	1	4		
2	27									1	3	1	2	1		3	3	2			
3	17									2				1	2	1	3	1	2	1	
4	9														1		1			1	
5	3																				1
6	14																1			2	2
7	8																			2	4
8	3																				
11	1																				
Larvæ..	331	3	3	3	4	5	6	7	10	17	14	18	16	11	11	19	25	12	16	16	12

Date of entering fruit.	Number of individuals.	Length of feeding period in specified days.																			
		41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	58	59	63	67	68
Aug. 20	27						1	1		1				1							
21	16										1										
22	23					2		1	2	2					1						
23	16		1	1	1																
24	9	1																			
25	17		1			1															
26	23	2	1			1	3				1			1	1					1	
27	19			1		2		2		1											
28	16	1			1	2	2														
29	18		1		1						1										1
30	13			1	1			2						1				1			1
31	29	2					1								1			1		1	
Sept. 1	23			2	1	1												1	1		
2	27	1		1	2		1				2		1			2	1				
3	17				1	1	2														
4	9	2			1				1						1	1					
5	3	1													1						
6	14	1				3					1	1				1		2			
7	8										1				1						
8	3					1				1					1						
11	1																			1	
Larvæ..	331	11	4	6	9	14	10	6	3	5	7	1	1	3	7	4	1	5	1	3	2

	Days.
Average length of feeding period	37.55
Maximum length of feeding period	68
Minimum length of feeding period	20

CODLING MOTH BAND STUDIES OF 1916.

The same orchards, the Edwards and Hamilton, that were used in the band studies in 1915 were again made use of in 1916. As in 1915, the larvæ were collected every three days from beneath burlap bands that encircled the trunks of certain trees and were kept under conditions identical with those that obtained the previous season.

The data from the studies of the larvæ collected in the Edwards orchard are given in Table LVI, in which it will be found that 50 collections were made beginning June 17 and ending November 11. During this period 4,998 larvæ were collected. Figure 31 represents the rate at which the larvæ were leaving the fruit during the three-day intervals throughout the season. It will be noted in the table that 49.19 per cent of the larvæ transformed to the adult stage in 1916, and that the remainder, 50.81 per cent, were wintering individuals. None of the larvæ collected in this orchard after August 19 transformed until the spring of the following year. The percentage of moths emerging in 1916 from each collection is shown diagrammatically in figure 32.

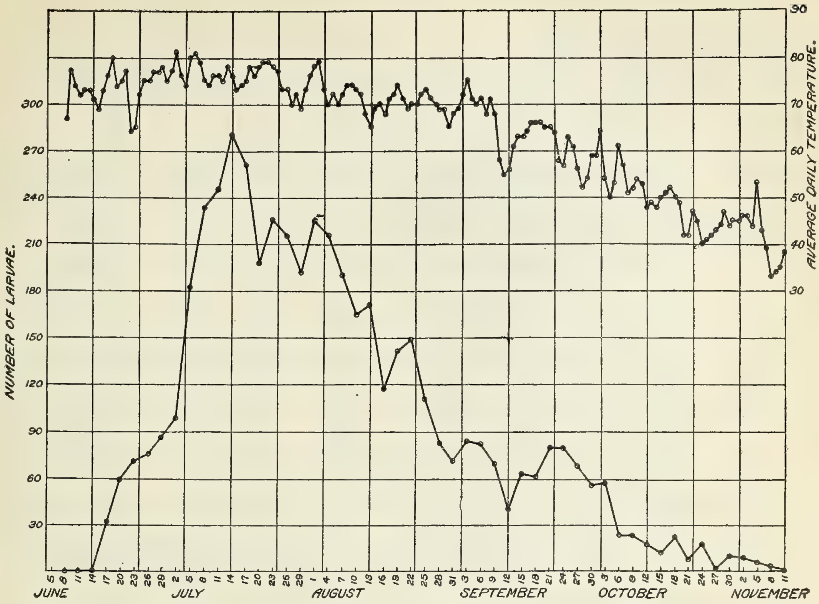


FIG. 31.—Number of codling moth larvæ collected from banded trees, Edwards orchard, Grand Junction, Colo., 1916.

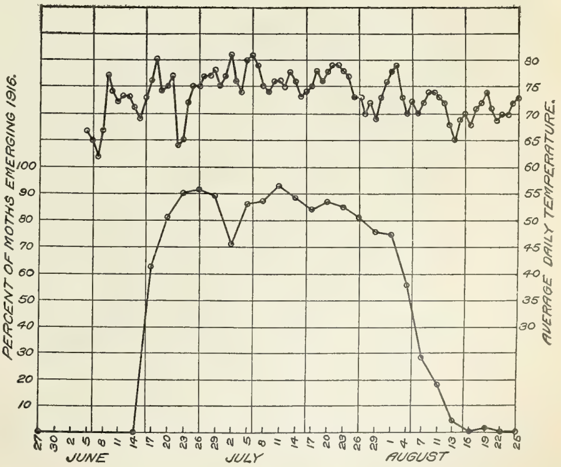


FIG. 32.—Percentage of codling moths emerging from band-collected material, Edwards orchard, Grand Junction, Colo., 1916.

TABLE LVI.—*Band-record experiment.—Codling moth larvæ collected at the Edwards orchard, Grand Junction, Colo., 1916.*

Date of collection, 1916.	Collection No.	Number of larvæ collected	Total number of moths emerging, 1916.	Per cent of— Moths emerging, 1916.	Per cent of— Individuals wintering.	Date of collection, 1916.	Collection No.	Number of larvæ collected.	Total number of moths emerging, 1916.	Per cent of— Moths emerging, 1916.	Per cent of— Individuals wintering.
June 17	1	32	20	62.50	37.50	Sept. 3	27	84	0	0.00	100.00
20	2	59	48	81.35	18.65	6	28	82	0	0.00	100.00
23	3	71	64	90.14	9.86	9	29	69	0	0.00	100.00
26	4	76	69	90.78	9.22	12	30	40	0	0.00	100.00
29	5	86	69	89.23	19.77	15	31	64	0	0.00	100.00
July 2	6	98	70	71.42	25.58	18	32	62	0	0.00	100.00
5	7	182	157	86.26	13.47	21	33	80	0	0.00	100.00
8	8	233	202	86.69	13.31	24	34	80	0	0.00	100.00
11	9	245	228	93.06	6.94	27	35	68	0	0.00	100.00
14	10	280	246	87.85	12.15	30	36	56	0	0.00	100.00
17	11	261	219	83.90	16.10	Oct. 3	37	58	0	0.00	100.00
20	12	198	172	86.86	13.14	6	38	24	0	0.00	100.00
23	13	226	192	84.95	15.05	9	39	24	0	0.00	100.00
26	14	215	175	81.39	18.61	12	40	18	0	0.00	100.00
29	15	192	146	76.04	23.96	15	41	13	0	0.00	100.00
Aug. 1	16	225	169	75.11	24.89	18	42	23	0	0.00	100.00
4	17	216	121	56.01	43.99	21	43	8	0	0.00	100.00
7	18	190	54	28.42	71.58	24	44	18	0	0.00	100.00
10	19	165	30	18.18	81.82	27	45	2	0	0.00	100.00
13	20	171	6	3.50	96.50	30	46	10	0	0.00	100.00
16	21	117	0	0.00	100.00	Nov. 2	47	9	0	0.00	100.00
19	22	142	2	1.40	98.60	5	48	6	0	0.00	100.00
22	23	149	0	0.00	100.00	8	49	4	0	0.00	100.00
25	24	111	0	0.00	100.00	11	50	2	0	0.00	100.00
28	25	83	0	0.00	100.00						
31	26	71	0	0.00	100.00		Total..	4,998	2,459	49.19	50.81

In the Hamilton orchard 46 collections of larvæ were made, beginning on June 17 and ending October 30, following the harvest of the fruit. A total of 5,716 larvæ was collected as will be seen by reference to Table LVII. Of this number 33.60 per cent transformed to the imago in 1916 and 66.40 per cent wintered. The percentage of transforming larvæ from each collection in 1916 is shown in the graph, figure 33. No larvæ transformed in 1916 from any collection made in this orchard after August 22. Figure 34 represents the number of larvæ collected from banded trees at each interval.

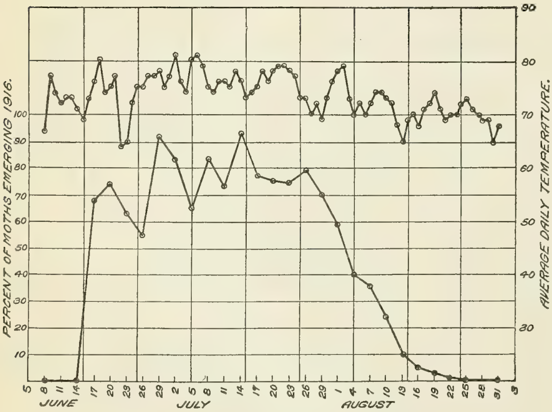


FIG. 33.—Percentage of codling moths emerging from band-collected material, Hamilton orchard, Grand Junction, Colo., 1916.

In figure 35 the graph is intended to show the average daily temperatures and the number of first and second brood moths that

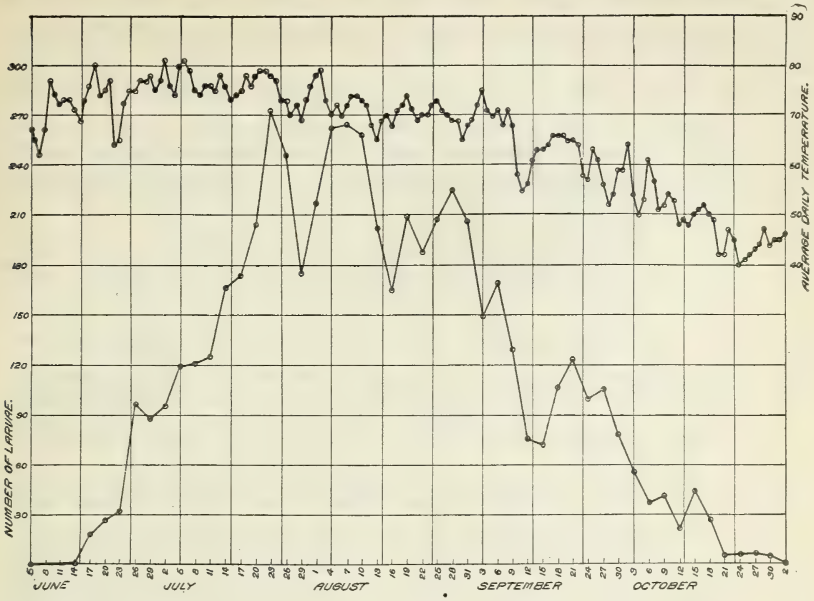


FIG. 34.—Number of codling moth larvæ collected from banded trees, Hamilton orchard, Grand Junction, Colo., 1916.

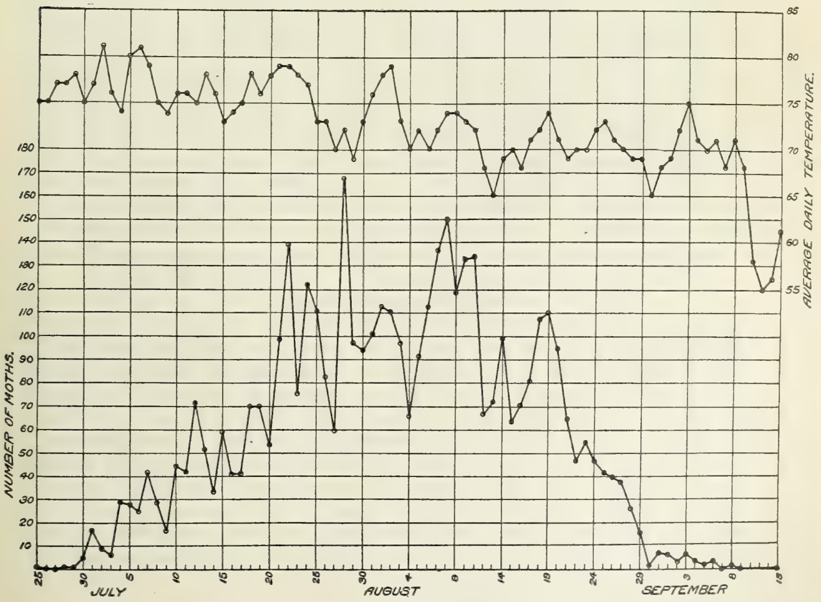


FIG. 35.—Time of emergence of codling moths from band-collected material, Hamilton and Edwards orchards, Grand Junction, Colo., 1916.

emerged from the larvæ collected from the banded trees at both the Edwards and Hamilton orchards. The first moth emerged June 25, the last September 8, a period of about two and a half months. The highest number of moths that issued in one day from this combined material was 167 on July 28, and this day was almost midway between the date of the first and last emergence. It will be recalled that, according to the insectary bred material, there was an overlapping of the first and second brood moths from August 7 to August 19 and that August 13 was theoretically considered as the dividing line between the two broods.

TABLE LVII.—*Band-record experiment, codling moth larvæ collected at the Hamilton orchard, Grand Junction, Colo., 1916.*

Date of collection, 1916.	Collection No.	Number of larvæ collected	Total number of moths emerging, 1916.	Per cent of—		Date of collection, 1916.	Collection No.	Number of larvæ collected.	Total number of moths emerging, 1916.	Per cent of—	
				Moths emerging, 1916.	Individuals wintering.					Moths emerging, 1916.	Individuals wintering.
June 17	1	19	13	68.42	31.58	Aug. 28	25	225	0	0.00	100.00
20	2	27	20	74.07	25.93	31	26	206	0	0.00	100.00
23	3	32	20	62.50	37.50	Sept. 3	27	149	0	0.00	100.00
26	4	96	53	55.20	44.80	6	28	169	0	0.00	100.00
29	5	88	81	92.04	7.96	9	29	129	0	0.00	100.00
July 2	6	95	79	83.15	16.85	12	30	76	0	0.00	100.00
5	7	119	77	64.70	35.30	15	31	72	0	0.00	100.00
8	8	121	100	82.64	17.36	18	32	106	0	0.00	100.00
11	9	125	91	72.80	27.20	21	33	123	0	0.00	100.00
14	10	165	154	93.33	6.67	24	34	99	0	0.00	100.00
17	11	173	134	77.45	22.55	27	35	105	0	0.00	100.00
20	12	204	153	75.00	25.00	30	36	78	0	0.00	100.00
23	13	272	201	73.89	26.11	Oct. 3	37	56	0	0.00	100.00
26	14	246	194	78.86	21.14	6	38	37	0	0.00	100.00
29	15	175	122	69.71	30.29	9	39	41	0	0.00	100.00
Aug. 1	16	217	128	58.98	41.02	12	40	22	0	0.00	100.00
4	17	262	106	40.45	59.55	15	41	44	0	0.00	100.00
7	18	264	94	35.60	64.40	18	42	27	0	0.00	100.00
10	19	258	63	24.41	75.59	21	43	6	0	0.00	100.00
13	20	202	21	10.39	89.61	24	44	6	0	0.00	100.00
16	21	164	8	4.87	95.13	27	45	7	0	0.00	100.00
19	22	209	6	2.87	97.13	30	46	5	0	0.00	100.00
22	23	[1] 188	1	[2] 0.54	[2] 99.46						
25	24	207	0	0.00	100.00		Total..	5,716	1,919	[2] 33.60	[2] 66.40

[1] 5 larvæ killed in handling.

[2] All percentages based upon number of live larvæ collected.

NATURAL ENEMIES OF THE CODLING MOTH.

PREDACIOUS ENEMIES.

The codling moth in the Grand Valley is seldom attacked by predacious insects and, as a result, the reduction of the pest by this means is quite inconsequential. A small beetle, *Tenebroides corticalis* Melsh., which, in its larval and adult stages, is known to feed upon the codling moth larva, was occasionally taken from beneath the bands on apple trees. A spider, *Coriarachne versicolor* Keys., was found from time to time feeding upon larvæ of the codling moth. This spider is a general feeder and is commonly found beneath the loose bark of orchard and shade trees.

In view of the comparative absence of predacious insect enemies an attempt was made to introduce the well-known beetle *Calosoma* *sycophanta* L., which has been instrumental in partially reducing the number of brown-tail moth and gipsy moth larvæ as well as other lepidopterous larvæ of the New England States. Over 1,000 of these beetles were released in June, 1915, but none were recovered after their distribution.

PARASITIC ENEMIES.

The parasitic enemies of the codling moth in the Grand Valley play a very unimportant rôle in its control, although in one instance an egg parasite, *Trichogramma minutum* Riley, was found quite abundant in the field in a small pear orchard. Some of the foliage surrounding the fruit was pulled at random and then was examined for eggs. Out of the first 100 eggs found, 15 were parasitized by this insect. As many as three of these parasites were found developing within one codling moth egg, while quite frequently two of the parasites inhabited the same egg.

Another parasite, *Dibrachys clisiocampae* Fitch, was found to attack the codling-moth larva and continue to feed upon the host after it had transformed to the pupa stage.

The parasite *Arthrolytus apatelae* Ashmead was also reared from material collected in the field.

In general, the occurrence of parasitism was so infrequent that little good was accomplished by this class of natural enemies.

MISCELLANEOUS STUDIES.

EFFECT OF COOL TEMPERATURES ON EMERGENCE OF MOTHS OF THE SPRING BROOD.

In laboratory cellar.—As a means of studying the influence of cool temperatures upon the emergence of moths of the spring brood, a number of wintering larvæ were placed in the cellar of the laboratory. This cellar was of the usual type, having stone walls and a cement floor, and was moderately dry. The temperature and atmospheric conditions within would compare somewhat with the fruit cellars or caves in which fruit is sometimes stored in the Grand Valley. The cage containing the insects was examined daily and the results of the observations will be found in Table LVIII.

A study of this table will show that the first moth, under cellar conditions, did not emerge until May 30, or 18 days after the first adult appeared in the outdoor insectary. It is noteworthy that the last emergence of moths in the cellar cage and the insectary cages occurred the same day, June 29. From these observations it would appear that the lower temperature in the cellar had a retarding influence in the development of the insect for some time, but that after the insects had been subjected to a sufficient accumulation of effective temperatures, their complete transformations to the adult stage were not long delayed.

TABLE LVIII.—*Emergence of codling moths of the spring brood, laboratory cellar, Grand Junction, Colo., 1915.*

Date of observation and collection.	Number of moths.	Date of observation and collection.	Number of moths.	Date of observation and collection.	Number of moths.	Date of observation and collection.	Number of moths.	Date of observation and collection.	Number of moths.
May 30	1	June 10	3	June 15	6	June 20	9	June 27	2
31	2	11	6	16	15	21	2	28	3
June 6	4	12	3	17	7	22	2	29	2
7	1	13	1	18	13	23	1		
8	3	14	2	19	8	26	4	Total.	105
9	5								

In fruit cellar.—Observations were also taken of the time of emergence of moths of the spring brood in a fruit cellar beneath a large packing house where considerable wormy fruit had been temporarily stored the previous fall. The records are from moths secured from a cage containing wintering larvæ and also from moths captured at a screened window. The observations were made only on the dates recorded in Table LIX. In this table it will be seen that 105 moths emerged in the cage, while 48 were captured at the window. In the latter connection it should be borne in mind that the records of the insects found at the window do not necessarily indicate the true time of their emergence. The emergence period of the caged insects in the fruit cellar was somewhat similar to that in the laboratory cellar.

It will be observed from the foregoing that moths may be expected to emerge from fruit cellars later than those out-of-doors, and this emergence augments, to a certain extent, the late injury as caused by the first brood of larvæ.

TABLE LIX.—*Emergence of codling moths of the spring brood, cellar of fruit packing house, Grand Junction, Colo., 1915.*

Date of observation and collection.	Number of moths—		Date of observation and collection.	Number of moths—		Date of observation and collection.	Number of moths—	
	In cage.	Found at screened window.		In cage.	Found at screened window.		In cage.	Found at screened window.
June 2	1	0	June 19	5	2	July 3	0	2
8	21	0	21	6	16	7	1	8
12	32	0	23	3	3	26	0	1
15	26	0	24	1	4			
16	7	1	29	2	11	Total	105	48

TIME OF DAY MOTHS EMERGE.

During the seasons of 1915 and 1916 observations were made to obtain data relative to the time of day the moths of the spring and first broods emerged in largest numbers. These studies are reported herewith.

Moths of the spring brood, 1915.—A certain lot of wintering larvæ were placed in cages with the view to determining at what periods of the day the moths of the spring brood emerge. The observations were taken at 8 a. m., noon, and 6 p. m. from May 14 to May 28, inclusive. It will be noted in Table LX that 1,189 moths issued during the 15-day period; 60, or 5.05 per cent, issued between 6 p. m. and 8 a. m.; 928, or 78.05 per cent, between 8 a. m. and 12 o'clock noon, and 201 moths, or 16.90 per cent, between 12 noon and 6 p. m.

TABLE LX.—*Emergence of codling moths of the spring brood, Grand Junction, Colo., 1915.*

Date of observation.	Number of moths emerging—			Date of observation.	Number of moths emerging—		
	6 p. m. to 8 a. m.	8 a. m. to 12 noon.	12 noon to 6 p. m.		6 p. m to 8 a. m.	8 a. m. to 12 noon.	12 noon to 6 p. m.
May 14	0	0	19	May 23	0	104	20
15	9	23	13	24	5	175	17
16	0	114	12	25	9	109	0
17	34	98	16	26	0	25	22
18	0	21	8	27	0	75	29
19	1	28	0	28	1	75	24
20	1	0	0				
21	0	3	5	Total..	60	928	201
22	0	78	16	Per ct..	5.05	78.05	16.90

Moths of the first brood, 1915.—Records of the emergence of moths of the first brood were taken hourly from 6 a. m. to 6 p. m., inclusive, and again at 9 p. m. and 12 o'clock midnight from August 16 to 20, inclusive. A total of 641 moths was used in this study, the details of which are given in Table LXI, in which it will be observed that no moths issued between midnight and 6 a. m., nor did any emerge between 6 a. m. and 7 a. m. During the 5-hour interval from 9 a. m. to 2 p. m., 431 moths, or 67.24 per cent, issued. The maximum emergence for any one hour occurred during the period from 9 a. m. to 10 a. m. From 6 p. m. to 7 a. m., a period of 13 hours, there emerged 35 moths, or 5.46 per cent of the total.

TABLE LXI.—*Emergence of codling moths of the first brood, hourly, from 6 a. m. to 6 p. m., and at 9 p. m. and 12 midnight, Grand Junction, Colo., 1915.*

Date of emergence of moths.	Observation No.	Number of moths emerging at—															Total number of moths.
		A. M.							P. M.								
		6	7	8	9	10	11	12	1	2	3	4	5	6	9	12	
Aug. 16	1	....	....	....	....	3	14	2	6	4	7	5	3	1	5	....	50
17	2	....	....	....	....	48	36	18	3	8	2	7	12	8	10	....	152
18	3	....	....	....	16	24	25	11	12	11	10	14	12	1	6	1	143
19	4	....	....	1	9	34	22	20	25	12	8	8	10	9	3	....	161
20	5	....	....	1	1	25	21	16	18	13	13	8	6	3	8	2	135
Total.	....	0	0	2	26	134	118	67	64	48	40	42	43	22	32	3	641

Moths of the spring brood, 1916.—Observations of the time of emergence of moths of the spring brood were made hourly from 7 a. m. to 6 p. m. from May 17 to 31, inclusive, as recorded in Table LXII. It will be noted therein that the largest number of moths issued between 12 o'clock noon and 1 p. m. The heaviest emergence period was the five-hour interval from 9 a. m. to 2 p. m., during which 895 moths, or 67.14 per cent of the total number of 1,333 moths, issued. Only 40 moths, or 3 per cent of the total, emerged during the period of 13 hours from 6 p. m. until 7 a. m.

TABLE LXII.—*Emergence of codling moths of the spring brood, hourly, from 7 a. m. to 6 p. m., Grand Junction, Colo., 1916.*

Date of emergenc of moths.	Observation No.	Number of moths emerging at—												Total number of moths.
		A. M.						P. M.						
		7	8	9	10	11	12	1	2	3	4	5	6	
May 17	1	....	....	....	.....	.....	10	34	5	2	2	....	....	53
18	2	1	....	....	1	30	19	9	4	6	....	....	....	70
19	3	....	4	4	27	27	27	15	18	5	3	....	1	131
20	4	....	....	....	.....	.....	.....	.....	.....	....	....	....	....	0
21	5	....	....	....	.....	.....	.....	.....	.....	....	7	2	2	11
22	6	....	1	....	7	21	40	49	19	12	2	5	1	157
23	7	....	....	....	.....	29	50	32	17	14	5	2	....	149
24	8	[1]37	29	55	34	25	8	13	15	6	10	7	6	245
25	9	1	1	....	.....	.....	.....	17	25	15	1	1	1	62
26	10	....	....	....	.....	.....	.....	15	20	3	2	....	....	40
27	11	....	....	....	.....	.....	3	24	11	8	3	1	....	50
28	12	....	....	....	.....	50	24	18	7	6	3	1	....	109
29	13	....	....	....	2	21	15	19	19	10	5	....	....	91
30	14	1	....	2	40	23	14	13	5	3	4	5	....	110
31	15	....	....	....	12	12	8	8	8	2	1	3	1	55
Total.	....	40	35	61	123	238	218	266	173	92	48	27	12	1,333

[1] About 5 of these moths found at 7 a. m. were spreading their wings, having emerged between 6 and 7 a. m.

Moths of the first brood, 1916.—A study of the time of emergence of first-brood moths was begun July 17 and ended August 4, and during this time observations were taken hourly from 6 a. m. to 6 p. m. The record of the observations shows that a total of 1,761 moths emerged, as is given in Table LXIII. The maximum emergence for a 1-hour period was 213 moths, which issued from 9 to 10 a. m. During the 5-hour period from 9 a. m. to 2 p. m. 923 issued, or 52.41 per cent of the total number of moths emerging. For the 13-hour period from 6 p. m. to 7 a. m. 61 moths, or 3.46 per cent. emerged.

From the foregoing studies it will be noted that the majority of the moths of the spring and first broods emerged during the latter part of the morning and early part of the afternoon, with the maximum emergence usually occurring from 9 to 11 a. m. During the 5-hour period from 9 a. m. to 2 p. m. from 52 to 67 per cent of the moths emerged; whereas during the 13-hour interval from 6 p. m. to 7 a. m. only from 3 to 5 per cent issued.

TABLE LXIII.—*Emergence of codling moths of the first brood, hourly, from 6 a. m. to 6 p. m., Grand Junction, Colo., 1916.*

Date of emergence of moths.	Observation No.	Number of moths emerging at—													Total number of moths.
		A. M.							P. M.						
		6	7	8	9	10	11	12	1	2	3	4	5	6	
July 17	1	....	....	....	3	6	6	5	1	5	2	4	6	3	41
18	2	....	....	1	.....	11	13	11	7	9	6	3	5	3	69
19	3	1	....	1	4	7	9	12	4	8	4	11	7	3	71
20	4	....	2	1	1	1	5	2	7	8	1	12	5	8	53
21	5	1	3	1	9	13	9	8	11	12	13	10	5	1	96
22	6	4	....	....	8	20	32	21	12	9	16	10	5	4	141
23	7	2	2	2	8	25	15	5	5	4	1	2	2	3	76
24	8	....	....	....	1	.....	5	12	16	10	22	15	32	6	119
25	9	3	1	....	4	10	18	16	6	.....	9	11	25	8	111
26	10	3	1	....	2	3	4	1	5	6	4	18	21	9	77
27	11	9	1	5	8	6	4	2	4	11	12	6	.....	....	68
28	12	1	....	....	19	26	6	4	9	16	35	30	18	3	167
29	13	1	1	....	2	5	7	8	16	15	8	13	11	7	94
30	14	4	2	....	4	26	20	1	3	4	3	7	10	7	91
31	15	7	....	....	8	12	4	2	20	16	13	10	5	6	103
Aug. 1	16	5	....	1	12	20	16	15	18	10	1	6	11	2	117
2	17	1	3	....	10	11	27	25	9	7	8	5	4	....	110
3	18	1	1	3	7	4	5	9	22	13	8	13	9	2	97
4	19	1	....	....	4	7	1	2	3	2	11	3	9	17	60
Total..	....	44	17	15	114	213	206	161	178	165	177	189	190	92	1,761

CODLING-MOTH FLIGHT TRIALS.

In connection with the habits of the codling moth, the question, "How far does the codling moth fly?" has frequently been asked, but it has not been possible to answer this query definitely on account of the lack of satisfactory data. It is generally conceded by the fruit growers of the Grand Valley that the codling moth migrates to a certain extent. They have observed that the outside rows of their orchards frequently have a greater percentage of wormy fruit, which they attribute to the immigration of moths from near-by orchards. It has also been found that the fruit on trees in the vicinity of the packing houses is, as a rule, quite wormy, due to the migration of the moths from the packing houses.

According to the observations of the writers, it is believed that the codling moth does not migrate long distances in a continuous flight, but by means of short flights may proceed from one tree to the next or fly across a road from one orchard to the adjoining or from the packing house to the neighboring trees, or occasionally fly a few hundred feet from one orchard to another. The normal flight, however, is restricted, as my be noted about dusk, when the moths are most active and may be seen flitting about in a tree or flying from one tree to another near by.

Perhaps the strongest evidence that the moths do not migrate in large numbers to any considerable extent was noted in 1915, when only a few smudged orchards, outside of the Palisade district, had a fruit crop. While the apples in these protected orchards were quite wormy, it is believed that had there been a large influx of moths from the hundreds of acres of surrounding orchards in which there was no fruit, it would have been practically impossible to have saved the crop with the normal spraying schedule.

In order to determine how far the adults can actually fly, it was thought desirable to make some moth-flight tests. Accordingly, trials were made on the mornings of June 11, 17, 24, July 27, 29, and August 3, 1915. These tests were usually made early in the morning and, in so far as possible, when the atmosphere was quiet and the temperature moderately low in order that the moths would fly at a slow speed. When the wind is moderate to strong or the temperature high, the moths are very rapid in their flight, so that it is impossible to follow them.

The moths were released one at a time from a central point, and Mr. Van Leeuwen and the senior author followed their course on foot. In all, several hundred moths were released and out of this number it was possible to secure data on a few. In many instances the moths ascended high into the air and were lost from view, in other instances they dropped into bushes, while in some cases their flight was either too erratic or swift to follow. The flight of the male moths was generally much more irregular and speedy than that of the other sex.

In determining the distance covered, measurements were made from the starting point to the place where the moths dropped or were lost from view. It should be noted, however, that the actual distance between the starting and finishing points, as measured by pacing, was usually only a small part of the distance the moths flew, since they seldom went in a straight line and it was impossible to take into account the numerous deviations from a direct course. Nevertheless, an attempt was made to estimate the number of feet actually traveled during the flight whenever the moths proceeded in a new direction for a considerable distance. This was done by counting the steps of the observers and allowing a certain distance per step. In this connection it should be borne in mind that the estimated distances, although approximate, are conservative.

In Table LXIV the flight records of 35 moths are given. Three of these covered a distance of over a thousand feet in one flight, measuring from the point of release to the place where the moths disappeared from view or dropped to the ground. The maximum air-line distance of 1,344 feet was made by a male moth. One female moth that flew, in 6½ minutes, a distance of 1,035 feet measured in a straight line, traveled an estimated distance of 3,000 feet and was still flying when it disappeared from sight. Another female moth, after flying continuously for 7½ minutes, was lost from view.

It would seem from the foregoing that the codling moth is capable of making a fairly long and sustained flight, but it does not necessarily follow from this that the moth naturally migrates to any considerable extent.

TABLE LXIV.—*Flight records of the codling moth, Grand Junction, Colo., 1915.*

Moth No.	Sex of moth.	Date of flight.	Actual distance between starting and finishing points.	Estimated distance of flight between starting and finishing points.	Remarks.
			Feet.	*Feet.*	
1	....	June 11	105	....	In two flights.
2	Male....	...do....	120	....	Lost from view.
3	...do....	...do....	360	720	Dropped to ground; when released, flew from sight.
4	...do....	...do....	138	....	On wing 2 minutes, then lost from view.
5	Female.	...do....	189	....	Do.
6	...do....	...do....	840	2,500	On wing 5 minutes, then lost from view.
7	...do....	...do....	600	1,800	On wing 7½ minutes, then lost from view.
8	...do....	...do....	420	1,200	In two flights, on wing 6½ minutes, then lost from view.
9	...do....	...do....	180	....	Flew out of sight.
10	....	June 17	390	600	On wing 3 minutes, then lost from view.
11	....	...do....	579	750	On wing 4 minutes, then lost from view.
12	Male....	...do....	249	....	On wing 1 minute, then lost from view.
13	Female.	June 24	715	....	On wing 1½ minutes, then lost from view; swift flier.
14	...do....	...do....	294	....	On wing 1¼ minutes, then lost from view.
15	...do....	...do....	135	....	Dropped to bushes.
16	...do....	...do....	276	....	On wing 1½ minutes, dropped to bushes.
17	...do....	...do....	180	350	On wing 2 minutes, then lost from view.
18	...do....	...do....	717	1,000	On wing 2½ minutes, then lost from view.
19	Male....	...do....	507	....	Very erratic; exhausted after 6-minute flight.
20	...do....	July 27	102	....	Dropped to bushes.
21	....	...do....	699	749	On wing 2 minutes.
22	Female.	...do....	1,035	3,000	On wing 6½ minutes, then lost from view
23	...do....	...do....	910	....	Lost from view.
24	...do....	...do....	595	....	On wing 2 minutes.
25	Male....	...do....	336	....	On wing 1 minute.
26	...do....	...do....	150	....	
27	Female.	...do....	1,155	....	On wing 4 minutes, then lost from view
28	Male....	...do....	1,344	....	
29	Female.	July 29	117	....	
30	Male....	...do....	590	....	
31	Female.	...do....	792	....	
32	....	...do....	1,356	....	In two flights.
33	Female.	Aug. 3	747	....	Dropped to ground, apparently exhausted
34	Male....	...do....	789	....	In two flights, on wing 2 minutes.
35	Female.	...do....	423	....	In three flights, on wing 1¾ minutes.

TIME OF COPULATION.

Observations of the time of copulation of the codling moth were taken during the seasons of 1915 and 1916. (See Pl. I, B.) The data for 1916 are more extensive than those for the preceding year. No attempt was made to watch the moths closely at all times, but instead they were examined at intervals to note if they had separated.

In 1915 the following records were secured:

Moths of the spring brood.—May 30, one pair found in copula at 7 p. m.; June 8, one at 6.50 a. m.; June 9, one at 6.45 a. m., and another pair at 7 a. m.

Moths of the first brood.—The data for moths of this brood are presented in Table LXV.

The observations in 1916 of the copulatory period of moths are given in two tables: Table LXVI for moths of the spring brood and Table LXVII for moths of the first brood.

TABLE LXV.—*Observations of the copulatory period of codling moths of the first brood, Grand Junction, Colo., 1915.*

Pair No.	Date found in copula.	Time found in copula.	Moths separated.	Minimum time attached.	
				Hours.	Minutes.
1	Aug. 7	8.00 a. m.	After 10 a. m.	2	....
2	...do....	8.45 a. m.	After 2.30 p. m.	5	45
3	Aug. 10	6.30 a. m.	After 9 a. m.	2	30
4	Aug. 14	8.40 a. m.	After 3 p. m.	6	20
5	Aug. 16	7.00 a. m.	Before 3 p. m.	....	....
6	...do....	9.30 p. m.	After 12.45 a. m. (Aug. 17)	3	15
7	...do....	9.50 p. m.	After 12 midnight	2	10
8	...do....	9.55 p. m.	Before 12 midnight	....	....
9	Aug. 18	9.05 a. m.	Before 1.30 p. m.	....	....
10	Aug. 19	2.45 a. m.	Before 6 a. m.	....	....
11	...do....	......do......	After 7.15 a. m.	4	30
12	...do....	9.15 p. m.	Before 12 midnight	....	....

TABLE LXVI.—*Observations of the copulatory period of codling moths of the spring brood, Grand Junction, Colo., 1916.*

Pair No.	Date moths emerged.	Date found in copula.	Time found in copula.	Moths separated subsequent to—	Minimum time attached.	
					Hours.	Minutes.
			A. M.			
1	....	May 19	9.40	6.30 p. m.	8	50
2	May 16	May 25	10.30	6.06 p. m., May 26	31	36
3	May 19	May 30	10.50	1 p. m.	2	10
4	...do....	May 31	8.59	11.02 a. m.	2	3
5	May 22	...do....	7.59	3 p. m.	7	1
6	May 23	May 25	11.50	12 noon, May 27	48	10
7	...do....	May 30	10.23	10.55 a. m.	....	32
8	...do....	May 31	7.45	9.37 a. m.	1	52
9	...do....	June 2	7.58	1.40 p. m.	5	42
10	...do....	June 3	7.12	2.15 p. m	7	3
11	...do....	...do....	7.12	6.25 p. m.	11	13
12	...do....	...do....	7.14	6.25 p. m.	11	11
13	May 24	May 31	7.29	8.06 a. m.	....	37
14	...do....	June 2	7.00	1.40 p. m.	6	40
15	...do....	...do....	7.15	5.48 p. m.	10	33
16	...do....	June 13	7.45	1.48 p. m.	6	3
17	May 27	June 4	6.45	3.07 p. m.	8	22
18	...do....	June 5	6.45	11.15 a. m.	4	30
19	May 28	June 2	6.45	7 a. m.	....	15
20	May 29	...do....	6.25	5.48 p. m.	11	23
21	May 31	June 3	6.25	9.50 a. m.	3	25
22	June 3	June 20	7.25	1.30 p. m.	6	5
23	June 4	June 7	6.25	11 a. m.	4	35
24	...do....	June 9	6.35	2.30 p. m.	7	55
25	June 8	June 12	6.20	6.15 p. m.	11	55
26	June 11	June 13	6.15	6.15 p. m.	12	....
27	June 15	June 21	6.45	3 p. m.	8	15
28	June 16	June 23	6.50	5.45 p. m.	10	55

TABLE LXVII.—*Observations of the copulatory period of codling moths of the first brood, Grand Junction, Colo., 1916.*

Pair No.	Date moths emerged.	Date found in copula.	Time found in copula.	Moths separated subsequent to—	Minimum time attached.	
					Hours.	Minutes.
			A. M.			
1	July 24	July 25	7.43	11.40 a. m	3	57
2	July 27	Aug. 2	7.20	4.50 p. m	9	30
3	July 28	July 31	7.13	12.15 p. m	5	2
4	...do	...do	7.19	12.15 p. m	4	56
5	Aug. 3	Aug. 5	6.54	2.37 p. m	7	43
6	...do	...do	9.52	6.00 p. m	8	8
7	Aug. 4	Aug. 11	7.29	5.48 p. m	10	19
8	Aug. 5	Aug. 7	7.00	4.55 p. m	9	55
8	...do	Aug. 8	7.05	12.19 p. m	5	14
9	Aug. 6	Aug. 13	6.20	10.09 a. m	3	49
10	...do	Aug. 20	7.45	10.00 p. m	14	15
11	Aug. 9	Aug. 12	7.06	2.45 p. m	7	39
12	Aug. 10	Aug. 15	7.25	12.10 p. m	4	45
13	Aug. 11	Aug. 13	6.00	10.40 a. m	4	40
14	Aug. 12	Aug. 23	7.45	8.02 a. m	....	17
15	Aug. 14	Aug. 17	7.20	11.27 a. m	4	7
16	...do	Aug. 20	6.50	3.55 p. m	9	5
17	...do	Sept. 1	7.40	Died previous to separation.		
18	Aug. 28	...do	7.00	8.05 a. m	1	5

TIME OF DAY MOTHS OVIPOSIT.

A series of studies was inaugurated in 1915 and continued in 1916 to ascertain the time of day the moths deposit their eggs most freely. The results of these studies are given herewith.

Moths of the first brood, 1915.—This experiment included 11 cages in which were confined a number of male and female moths. The observations were made at 3 p. m., 6 p. m., 9 p. m., 12 o'clock midnight, 6 a. m., 9 a. m. and 12 o'clock noon, or, in other words, daily every 3 hours except at 3 a. m. These studies were commenced at 12 o'clock noon August 16 and were concluded at 6 a. m. August 21. At each examination the old foliage was removed and a fresh supply furnished, and at the same time the number of eggs deposited on the sides of the cages was recorded and the eggs removed. Some eggs were deposited on the sand in the bottom of the jars, but as these could not be accurately counted, they were not taken into consideration.

In Table LXVIII the tabulated data of the time of deposition of 3,621 eggs will be found in addition to the mean temperatures during the periods of observation. This table has been summarized and the data presented in Table LXIX, by reference to which it will be noted that the great majority of the eggs were deposited between 12 o'clock noon and 9 p. m. The time of greatest deposition occurred just before dusk, the moths being very active at this time. It is of interest to note that with a mean temperature of 78.90° F. during 5 observation periods from 9 a. m. till 12 o'clock noon, only 2.34 per cent of the eggs were laid, whereas the moths laid much more abundantly with both higher and lower mean temperatures when these occurred later in the day.

TABLE LXVIII.—*Time of oviposition by codling moths of the first brood; observations taken daily every three hours, except at 3 a. m., Grand Junction, Colo., 1915.*

Cage No.—		1		2		3		4		5		6		7		8		9		10		11		Number of eggs deposited on—		Total number of eggs deposited.	Mean temperature between observations.
Moths emerged August—		10		10		10		11		11		12		12		12		13		13		13					
		Number of eggs deposited on—																									
Date of observation.	Time of observation.	Foliage.	Cage.	Foliage.	Cage.	Foliage.	Cage.	Foliage.	Cage.	Foliage.	Cage.	Foliage.	Cage.	Foliage.	Cage.	Foliage.	Cage.	Foliage.	Cage.	Foliage.	Cage.	Foliage.	Cage.	Foliage.	Cage.		
																											° *F.*
Aug. 16	12 m......	8	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	13	77.25
	3 p. m.....	28	22	5	19	25	3	24	5	63	18	7	10	125	29	0	5	30	24	0	10	9	68	316	213	529	79.00
	6 p. m.....	64	87	18	11	24	41	0	2	33	10	1	1	18	15	2	1	17	32	8	87	25	13	210	300	510	75.25
	9 p. m.....	6	8	3	1	0	3	0	0	4	1	0	1	0	0	38	1	0	0	0	3	12	0	63	18	81	67.50
	12 mt.....	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	2	60.25
17	6 a. m.....	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	3	3	55.00
	9 a. m.....	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	4	4	66.50
	12 m......	0	2	0	2	0	3	0	0	0	0	0	0	0	1	0	0	0	0	0	2	0	0	0	10	10	77.25
	3 p. m.....	0	3	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	15	15	17	18	35	87.25
	6 p. m.....	4	17	1	1	22	37	38	10	5	0	7	2	36	12	2	0	0	1	3	1	8	3	126	84	210	87.00
	9 p. m.....	38	20	15	0	15	46	16	11	131	2	10	1	31	11	32	2	2	2	45	32	28	14	363	141	504	74.25
	12 mt.....	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	3	0	5	5	63.00
18	6 a. m.....	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	59.43
	9 a. m.....	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	3	0	4	0	4	64.25
	12 m......	0	2	2	1	1	1	0	1	0	0	0	0	2	6	1	0	0	5	0	0	4	0	10	16	26	80.75
	3 p. m.....	3	9	0	0	3	3	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	7	14	21	90.00
	6 p. m.....	11	21	16	1	16	35	30	4	23	28	3	0	0	0	14	0	51	2	1	3	18	1	183	95	278	85.50
	9 p. m.....	28	25	9	3	5	33	13	0	36	21	7	1	31	0	19	0	2	0	41	21	30	1	221	105	326	74.25
	12 mt.....	0	0	0	0	0	3	0	1	0	1	0	3	0	0	0	0	0	2	0	0	0	1	0	11	11	63.50
19	6 a. m.....	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	57.43
	9 a. m.....	0	4	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	3	0	1	0	0	0	9	9	63.75
	12 m......	4	4	0	2	2	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	8	6	14	79.00
	3 p. m.....	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	7	0	0	0	8	2	10	89.00
	6 p. m.....	3	2	5	1	12	13	21	0	7	2	67	8	4	1	53	0	7	0	4	0	0	0	183	27	210	88.00
	9 p. m.....	14	10	14	1	6	26	20	0	32	9	65	13	15	3	56	6	4	4	2	11	26	3	254	86	340	75.25
	12 mt.....	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	4	0	0	1	5	6	66.75
20	6 a. m.....	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	59.86
	9 a. m.....	0	0	0	0	0	4	0	0	1	0	0	0	0	2	0	0	0	0	0	0	0	0	1	6	7	63.75
	12 m......	0	1	0	0	1	0	4	0	0	3	0	0	0	2	1	0	0	0	0	0	8	2	14	8	22	80.25
	3 p. m.....	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	3	0	3	90.50
	6 p. m.....	2	7	1	1	2	10	9	4	4	0	12	6	2	0	9	0	11	1	67	10	9	0	128	39	167	89.75
	9 p. m.....	6	8	12	0	17	11	25	0	15	11	10	1	19	2	12	2	1	2	60	17	10	0	187	54	241	77.25
	12 mt.....	0	9	0	0	0	1	0	0	0	1	0	1	1	0	0	0	0	0	1	2	0	0	2	14	16	66.50
21	6 a. m.....	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2	0	2	63.29
Total..	....	221	263	101	45	151	274	206	39	358	110	189	48	288	86	239	18	127	82	241	206	205	124	2,326	1,295	3,621	....

m=noon; mt.=midnight.

TABLE LXIX.—*Time of oviposition by codling moths of the first brood; observations taken daily every three hours, except at 3 a. m.; Grand Junction, Colo., 1915; summary of Table LXVIII.*

Number of observation periods.	Period of observation.	Total number of eggs deposited.	Average number of eggs per oviposition period.	Per cent of eggs deposited per oviposition period.	Mean temperature during oviposition periods.
					°*F.*
5	12 mt. to 6 a. m....	7	1.40	0.19	59.00
4	6 a. m. to 9 a. m...	24	6.00	.83	64.56
5	9 a. m. to 12 m.....	85	17.00	2.34	78.90
5	12 m. to 3 p. m....	598	119.60	16.49	87.15
5	3 p. m. to 6 p. m...	1,375	275.00	37.91	85.10
5	6 p. m. to 9 p. m...	1,492	298.40	41.14	73.70
5	9 p. m. to 12 mt....	40	8.00	1.10	64.00

m=noon; mt.=midnight.

Moths of the spring brood, 1916.—The study of the time of oviposition by moths of the spring brood was commenced at 12 o'clock noon on June 5 and the observations were made daily every 3 hours, except at 3 a. m., until 12 o'clock noon June 12, a period of one week. The details of this study are presented in Table LXX and summarized in Table LXXI. By reference to the latter it will be noted that over 79 per cent of the eggs were deposited from 3 p. m. to 9 p. m. It will be seen in the table that the mean temperature for the 7 days from 9 a. m to 12 o'clock noon was 76.39° F. Although this temperature is in no wise unfavorable for egg deposition, yet only 1.54 per cent of the eggs were deposited during this interval. Later in the day, with both higher and lower mean temperatures, much higher percentages of eggs were deposited. From 3 p. m. to 6 p. m. 58.80 per cent of the eggs were laid, the mean temperature being 82.92° F., or a little over 6° higher than the temperature from 9 a. m. to 12 o'clock noon. From 6 p. m. to 9 p. m., with a temperature of 73.14° F., 20.52 per cent of the eggs were deposited.

TABLE LXX.—*Time of oviposition by codling moths of the spring brood. Observations taken daily every three hours except at 3 a. m., Grand Junction, Colo., 1916.*

Cage No. —		1		2		3		4		5		6		7		8		9		10		Number of eggs deposited on—		Total number of eggs deposited.	Mean temperature between observations.
Moths emerged, May—		23		23		23		23		23		23		23		23		24		24					
		Number of eggs deposited on—																							
Date of observation.	Time of observation.	Foliage.	Cage.	Foliage.	Cage.	Foliage.	Cage.	Foliage.	Cage.	Foliage.	Cage.	Foliage.	Cage.	Foliage.	Cage.	Foliage.	Cage.	Foliage.	Cage.	Foliage.	Cage.	Foliage.	Cage.		
																									°*F.*
June 5	3 p. m...	0	0	0	0	16	0	0	0	0	0	2	0	3	0	0	0	0	0	1	4	22	4	26	81.25
	6 p. m...	15	0	18	0	1	0	0	0	0	0	1	0	2	0	0	0	0	0	0	3	37	3	40	78.75
	9 p. m...	1	0	1	1	1	0	0	0	0	0	2	0	2	0.	0.	4	0	0	0	0	7	5	12	70.75
	12 mt...	0	0	0	1	0	1	0.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	65.00
June 6	6 a. m...	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	53.71
	9 a. m...	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	56.75
	12 m....	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	70.75
	3 p. m...	1	1	0	0	10	0	3	0	0	1	2	0	2	0	0	0	2	0	0	0	20	2	22	78.50
	6 p. m...	19	2	3	0	0	2	8	0	5	0	4	0	4	0	0	0	0	0	0	0	43	4	47	78.50
	9 p. m...	1	4	0	0	3	5	0	2	0	0	0	0	0	0	0	0	0	0	0	0	4	11	15	68.50
	12 mt...	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	60.00
June 7	6 a. m...	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	49.14
	9 a. m...	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	55.00
	12 m....	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	9	0	9	68.25
	3 p. m...	0	0	1	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	6	0	6	76.25
	6 p. m...	5	1	24	0	7	2	5	0	2	0	1	0	6	0	3	4	0	0	0	0	53	7	60	77.50
	9 p. m...	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	4	0	0	0	0	1	5	6	68.00
	12 mt...	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	56.00
June 8	6 a. m...	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	49.28
	9 a. m...	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	57.50
	12 m....	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	71.50
	3 p. m...	4	2	0	1	15	0	3	0	0	0	1	0	0	0	0	0	0	0	0	0	23	3	26	84.00
	6 p. m...	2	1	2	0	15	0	36	0	34	0	0	0	1	0	0	0	0	1	0	0	90	2	92	85.25
	9 p. m...	4	2	19	0	0	1	6	2	0	0	0	0	0	0	0	0	0	0	0	0	29	5	34	76.75
	12 mt...	0	0	0	0	2	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5	7	67.75
June 9	6 a. m...	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	66.28
	9 a. m...	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	68.75
	12 m....	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	81.50
	3 p. m...	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	91.75
	6 p. m...	0	0	0	0	2	0	28	0	18	0	1	0	0	0	0	0	37	1	0	0	86	1	87	90.75

	9 p. m...	2	7	1	0	9	1	3	0	2	0	0	0	0	0	0	0	0	0	0	0	17	8	25	80.50
	12 mt...	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	74.00
June 10	6 a. m...	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	62.57
	9 a. m...	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	67.25
	12 m....	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	81.75
	3 p. m...	0	0	0	0	1	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	5	88.25
	6 p. m...	0	0	0	0	5	5	0	0	15	0	1	0	0	0	0	0	0	0	2	0	23	5	28	85.75
	9 p. m...	1	14	0	0	3	5	2	0	2	0	0	0	5	0	0	0	0	0	1	0	14	19	33	73.00
	12 mt...	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	66.50
June 11	6 a. m...	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	60.42
	9 a. m...	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	65.25
	12 m....	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	79.25
	3 p. m...	0	0	0	0	0	0	3	0	0	0	0	0	1	0	2	0	1	0	0	0	7	0	7	86.25
	6 p. m...	0	6	0	0	0	0	2	0	11	0	0	0	2	0	0	0	0	0	6	0	21	6	27	84.00
	9 p. m...	2	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	4	0	8	0	8	74.50
	12 mt...	0	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21	21	65.50
June 12	6 a. m...	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	58.14
	9 a. m...	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	68.00
	12 m....	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	81.50
Total.	....	57	61	69	3	91	30	103	4	89	1	20	0	31	0	5	12	49	2	14	7	528	120	648	......

m.=noon: mt.=midnight.

Table LXXI.—*Time of oviposition by moths of the spring brood; observations taken daily every three hours, except at 3 a. m.; Grand Junction, Colo., 1916; summary of Table LXX.*

Number of observation periods.	Period of observation.	Total number of eggs deposited.	Average number of eggs per oviposition period.	Per cent of eggs deposited per oviposition period.	Mean temperature during oviposition periods.
					°*F.*
7	12 mt. to 6 a. m.	0	0.00	0.00	57.07
7	6 a. m. to 9 a. m.	0	0.00	0.00	62.64
7	9 a. m. to 12 m.	10	1.42	1.54	76.39
7	12 m. to 3 p. m.	92	13.14	14.20	83.75
7	3 p. m. to 6 p. m.	381	54.42	58.80	82.92
7	6 p. m. to 9 p. m.	133	19.00	20.52	73.14
7	9 p. m. to 12 mt.	32	4.57	4.94	64.96

m=noon; mt=midnight.

Moths of the first brood, 1916.—Oviposition studies, similar to those just described, were made with moths of the first brood during a period of one week from July 24 to 31, inclusive. The results are given in Table LXXII and presented in a summarized form in Table LXXIII.

The eggs were deposited in largest numbers from 3 p. m. to 6 p. m., with the greatest activity about dusk. With a mean temperature of 79.28° F., from 3 p. m. to 6 p. m., over 35 per cent of the eggs were laid, whereas with a lower mean temperature, 72.96° F., from 6 p. m. to 9 p. m., over 46 per cent of the eggs were deposited.

It would appear from the foregoing studies that the time of day is the most influential factor relating to the time of oviposition by moths of the spring and first broods. The moths, as a rule, are most active in depositing their eggs late in the afternoon to early in the evening, their activity being greatest just about dusk.

TABLE LXXII.—*Time of oviposition by moths of the first brood; observations taken daily every three hours except at 3 a. m.; Grand Junction, Colo., 1916.*

Cage No.		1		2		3		4		5		6		7		8		9		10		11		12		13		14		Number of eggs deposited on—		Total number of eggs deposited.	Mean temperature between observations.
Moths emerged July		18		18		19		19		20		20		21		21		21		21		22		22		22		22					
Date of observation.	Time of observation.	Number of eggs deposited on—																															
		Foliage.	Cage.	Foliage.	Cage.	Foliage.	Cage.	Foliage.	Cage.	Foliage.	Cage.	Foliage.	Cage.	Foliage.	Cage.	Foliage.	Cage.	Foliage.	Cage.	Foliage.	Cage.	Foliage.	Cage.	Foliage.	Cage.	Foliage.	Cage.	Foliage.	Cage.	Foliage.	Cage.		
																																	° *F.*
July 24	3 p. m.	0	0	0	0	0	0	0	4	0	22	0	0	0	23	1	20	0	0	0	0	0	0	0	0	0	0	0	0	1	69	70	94.00
	6 p. m.	1	0	9	3	32	11	19	20	13	8	18	6	1	15	44	22	45	1	64	87	17	0	19	60	10	2	55	58	347	293	640	87.50
	9 p. m.	0	59	29	33	9	21	3	7	16	40	44	52	1	4	44	76	44	33	29	120	5	1	22	56	20	11	38	11	304	524	828	79.00
	12 mt.	47	31	0	3	2	29	21	9	8	14	1	0	2	5	4	6	0	10	0	2	0	0	19	1	22	15	1	1	127	126	253	74.75
25	6 a. m.	3	3	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	3	5	8	68.57
	9 a. m.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	72.75
	12 m.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	78.00
	3 p. m.	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	3	0	3	72.75
	6 p. m.	0	8	2	2	11	0	8	4	0	6	16	5	1	9	1	0	6	2	40	24	16	5	15	19	2	1	6	2	124	87	211	75.25
	9 p. m.	38	10	21	3	29	12	0	8	0	5	22	28	0	5	4	4	19	9	9	42	5	1	43	79	20	1	3	5	213	212	425	73.75
	12 mt.	0	0	0	0	0	1	0	1	0	0	5	0	0	0	0	2	0	2	1	3	0	1	0	0	0	0	0	0	6	10	16	71.50
26	6 a. m.	0	0	0	0	0	0	0	0	0	0	0	5	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	10	66.85
	9 a. m.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	3	3	68.50
	12 m.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29	0	0	0	0	0	29	29	78.50
	3 p. m.	3	0	0	0	0	0	0	0	5	0	5	0	0	0	0	0	6	1	0	7	1	0	3	10	0	0	0	0	23	18	41	76.25
	6 p. m.	0	5	1	2	8	5	3	3	0	14	41	14	1	11	14	17	26	5	28	50	2	0	11	43	32	6	3	6	170	181	351	81.25
	9 p. m.	6	0	9	2	56	0	21	1	1	1	56	1	0	4	26	4	0	1	59	49	69	0	9	23	1	2	12	2	325	90	415	75.75
	12 mt.	2	0	0	0	0	2	2	0	0	1	0	0	0	2	0	0	0	0	1	0	0	1	0	2	0	0	0	0	5	8	13	70.00
27	6 a. m.	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	2	3	66.42
	9 a. m.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	69.25
	12 m.	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	1	2	3	76.00
	3 p. m.	20	7	0	0	1	0	5	0	5	0	7	0	4	0	1	4	0	0	0	1	0	0	2	2	17	0	0	0	62	14	76	80.75
	6 p. m.	0	0	1	0	0	0	0	0	1	0	6	2	0	0	1	1	0	0	0	0	1	0	6	0	2	0	0	2	18	5	23	71.50
	9 p. m.	1	0	0	7	0	0	0	1	2	1	7	1	0	5	0	0	0	0	46	10	1	0	13	6	0	0	17	3	87	34	121	67.50
	12 mt.	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	2	1	0	0	0	0	0	0	0	2	0	0	3	4	7	66.00
28	6 a. m.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	64.71
	9 a. m.	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	7	67.50
	12 m.	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	1	9	2	0	0	2	0	0	0	20	3	23	78.25
	3 p. m.	0	0	0	2	5	1	0	0	1	10	6	1	0	0	0	0	0	0	10	0	0	0	0	10	2	0	0	0	24	24	48	84.75

m.=noon; mt.=midnight.

TABLE LXXII.—*Time of oviposition by moths of the first brood; observations taken daily every three hours except at 3 a. m.; Grand Junction, Colo., 1916*—Continued.

Cage No.		1		2		3		4		5		6		7		8		9		10		11		12		13		14		Number of eggs deposited on—		Total number of eggs deposited.	Mean temperature between observations.
Moths emerged July		18		18		19		19		20		20		21		21		21		21		22		22		22		22					
Date of observation.	Time of observation.	Number of eggs deposited on—																															
		Foliage.	Cage.	Foliage.	Cage.	Foliage.	Cage.	Foliage.	Cage.	Foliage.	Cage.	Foliage.	Cage.	Foliage.	Cage.	Foliage.	Cage.	Foliage.	Cage.	Foliage.	Cage.	Foliage.	Cage.	Foliage.	Cage.	Foliage.	Cage.	Foliage.	Cage.	Foliage.	Cage.		
																																	°*F.*
July 28	6 p. m.	1	0	1	1	11	0	1	0	2	1	8	0	0	7	5	4	26	25	20	0	5	0	4	13	17	0	5	7	106	58	164	76.50
	9 p. m.	0	0	0	0	0	0	1	1	2	2	0	0	9	5	0	0	4	3	15	20	3	0	2	12	0	1	2	0	38	44	82	69.50
	12 mt.	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2	2	66.25
29	6 a. m.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	3	3	63.85
	9 a. m.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	65.00
	12 m.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	67.50
	3 p. m.	0	0	0	0	0	0	0	0	0	5	0	0	0	1	0	0	0	0	0	1	7	0	0	3	0	0	1	0	8	10	18	75.75
	6 p. m.	1	2	0	1	0	7	0	0	0	2	0	0	2	4	0	0	0	0	9	15	1	0	13	18	2	1	3	7	31	57	88	79.50
	9 p. m.	1	0	0	0	3	0	0	0	0	0	0	0	0	0	22	9	0	0	5	8	0	0	0	6	2	0	4	1	37	24	61	73.00
	12 mt.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1	66.25
30	6 a. m.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	60.71
	9 a. m.	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	3	3	66.50
	12 m.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	78.50
	3 p. m.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	3	0	5	0	0	0	0	0	10	2	12	87.25
	6 p. m.	0	0	0	0	0	0	0	0	0	0	0	1	0	3	0	0	0	2	0	0	0	0	0	36	0	5	0	11	0	58	58	83.50
	9 p. m.	0	0	0	0	0	0	0	0	0	0	0	0	5	6	0	0	0	0	4	6	9	7	0	13	7	5	3	1	28	38	66	72.25
	12 mt.	0	0	0	0	3	0	13	0	0	0	2	3	2	0	0	0	2	0	17	0	6	5	6	0	0	3	27	0	78	11	89	72.50
31	6 a. m.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	67.14
	9 a. m.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	70.50
	12 m.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2	2	79.50
	Total	124	125	73	60	177	90	97	60	57	133	255	119	28	110	173	169	180	95	360	456	160	23	194	447	158	57	180	117	2,216	2,061	4,277	......

m.=noon; mt.=midnight.

TABLE LXXIII.—*Time of oviposition by moths of the first brood, observations taken daily every three hours, except at 3 a. m., Grand Junction, Colo., 1916; summary of Table LXXII.*

Number of observation periods.	Period of observation.	Total number of eggs deposited.	Average number of eggs per oviposition period.	Per cent of eggs deposited per oviposition period.	Mean temperature during oviposition periods.
					°*F.*
7	12 mt. to 6 a. m....	24	3.42	0.56	65.46
7	6 a. m. to 9 a. m...	13	1.85	0.30	68.57
7	9 a. m. to 12 m....	58	8.28	1.36	76.60
7	12 m. to 3 p. m....	268	38.28	6.27	81.64
7	3 p. m. to 6 p. m..	1,535	219.28	35.92	79.28
7	6 p. m. to 9 p. m..	1,998	285.00	46.68	72.96
7	9 p. m. to 12 mt...	381	54.42	8.91	69.60

m=noon; mt=midnight.

OVIPOSITION BY INDIVIDUAL MOTHS.

Studies of the fecundity of individual moths were made in 1915 and 1916 by isolating pairs of male and female moths in separate cages. These moths were segregated either one or two days after their emergence and were then confined in jelly-glass tumblers into which were placed daily fresh apple or pear foliage and a small piece of sponge moistened with newly made sugar solution. Each cage was examined daily for eggs.

Moths of the first brood, 1915.—As shown in Table LXXIV, the first moths in this study emerged July 26, while the last pair, No. 83, emerged August 19. The summarized results of the observations show that the 83 moths deposited a total of 3,762 eggs, or an average of 45.33 eggs per female. The maximum number of eggs laid by a single individual was 185; the average number of eggs laid by a single female in one day was 10.84 and the maximum 80.

Attention is here drawn to certain facts as revealed by a comparison of Tables XVI and LXXIV. It will be noted in the former table, which gives in detail the oviposition data of moths of the first brood confined, in 1915, in the usual large battery-jar cages, that 46.73 was the average number of eggs deposited per female moth, while 45.33 was the average number deposited per female by the individual caging method, as shown in the latter table. This latter method seems to have reduced the length of the period of oviposition as well as delayed it somewhat. However, as will be seen by a comparison of Tables XVII and LXXIV, the average length of life of the female moth was about the same by either method, it being 12.68 days when the moths were confined in the large battery-jar cages and 12.80 days when caged individually. A detailed record of this and other important oviposition data obtained by the individual caging method in 1915 is given completely in Table LXXIV.

TABLE LXXIV.—*Oviposition by individual codling moths of the first brood, Grand Junction, Colo., 1915.*

Pair No.	Date of—				Period (in days).				Total length of life of female moth	Number of days on which oviposition occurred.	Total number of eggs deposited.	Average number of eggs per oviposition.	Maximum number of eggs deposited in one day.
	Emergence of moths.	First oviposition.	Last oviposition.	Death of female moth.	Before oviposition.	Of oviposition.	From date of emergence to last oviposition.	Of life of female after oviposition.					
									Days.				
1	July 26	July 28	Aug. 3	Aug. 4	2	7	8	1	9	5	29	5.8	12
2	July 27	July 29	...do.....	Aug. 5	2	6	7	2	9	2	2	1.0	1
3	Aug. 2	Aug. 4	Aug. 10	Aug. 15	2	7	8	5	13	4	31	3.8	24
4	Aug. 4	Aug. 5	Aug. 5	Aug. 8	1	1	1	3	4	1	16	16.0	16
5	...do.....	Aug. 6	Aug. 6	Aug. 16	2	1	2	10	12	1	2	2.0	2
6	...do.....	...do.....	Aug. 14	...do.....	2	9	10	2	12	8	115	14.4	47
7	...do.....	...do.....	Aug. 13	Aug. 17	2	8	9	4	13	4	14	3.5	8
8	...do.....	...do.....	Aug. 11	Aug. 15	2	6	7	4	11	5	121	24.2	38
9	...do.....	...do.....	Aug. 12	...do.....	2	7	8	3	11	6	136	22.7	51
10	...do.....	...do.....	Aug. 9	Aug. 12	2	4	5	3	8	3	19	6.3	10
11	...do.....	...do.....	Aug. 15	Aug. 16	2	10	11	1	12	8	88	11.0	36
12	...do.....	...do.....	Aug. 13	Aug. 17	2	8	9	4	13	8	185	23.1	38
13	...do.....	...do.....	Aug. 16	...do.....	2	11	12	1	13	9	118	13.1	36
14	...do.....	Aug. 7	...do.....	Aug. 19	3	10	12	3	15	2	2	1.0	1
15	...do.....	...do.....	...do.....	...do.....	3	10	12	3	15	7	39	5.6	15
16	...do.....	...do.....	Aug. 11	Aug. 11	3	5	7	0	7	5	95	19.0	26
17	...do.....	Aug. 8	Aug. 13	Aug. 19	4	6	9	6	15	5	77	15.4	44
18	...do.....	...do.....	Aug. 9	Aug. 16	4	2	5	7	12	2	2	1.0	1
19	...do.....	Aug. 10	Aug. 13	...do.....	6	4	9	3	12	4	46	11.5	28
20	Aug. 6	Aug. 8	...do.....	Aug. 14	2	6	7	1	8	6	103	17.2	58
21	...do.....	...do.....	Aug. 9	Aug. 12	2	2	3	3	6	2	30	15.0	27
22	...do.....	...do.....	Aug. 10	Aug. 13	2	3	4	3	7	2	30	15.0	27
23	...do.....	...do.....	...do.....	...do.....	2	3	4	3	7	3	103	34.3	73
24	...do.....	Aug. 9	...do.....	...do.....	3	2	4	3	7	2	5	2.5	3
25	...do.....	Aug. 10	Aug. 18	Aug. 19	4	9	12	1	13	7	22	3.1	6
26	Aug. 7	Aug. 16	Aug. 20	Aug. 21	9	5	13	1	14	4	16	4.0	7
27	...do.....	Aug. 9	Aug. 14	Aug. 17	2	6	7	3	10	4	71	17.8	24
28	...do.....	Aug. 15	Aug. 15	...do.....	8	1	8	2	10	1	3	3.0	3
29	...do.....	Aug. 16	Aug. 16	...do.....	9	1	9	1	10	1	3	3.0	3
30	Aug. 8	Aug. 10	Aug. 17	Aug. 20	2	8	9	3	12	5	25	5.0	9
31	...do.....	...do.....	Aug. 11	Aug. 12	2	2	3	1	4	2	6	3.0	3
32	...do.....	Aug. 11	...do.....	Aug. 19	3	1	3	8	11	1	1	1.0	1
33	...do.....	Aug. 12	Aug. 12	Aug. 16	4	1	4	4	8	1	32	32.0	32
34	Aug. 9	Aug. 11	...do.....	Aug. 19	2	2	3	7	10	2	85	42.5	68
35	...do.....	Aug. 12	Aug. 16	Aug. 20	3	5	7	4	11	3	22	7.3	13
36	...do.....	...do.....	Aug. 22	Aug. 24	3	11	13	2	15	8	121	15.1	30
37	...do.....	...do.....	Aug. 16	Aug. 20	3	5	7	4	11	3	22	7.3	13
38	...do.....	Aug. 13	Aug. 15	Aug. 19	4	3	6	4	10	3	26	8.7	13
39	...do.....	Aug. 14	Aug. 14	Aug. 15	5	1	5	1	6	1	25	25.0	25
40	Aug. 11	...do.....	Aug. 21	Aug. 22	3	8	10	1	11	6	76	12.7	21
41	...do.....	Aug. 15	Aug. 20	...do.....	4	6	9	2	11	6	28	4.7	11
42	...do.....	...do.....	Aug. 15	Aug. 18	4	1	4	3	7	1	15	15.0	15
43	...do.....	...do.....	Aug. 27	Aug. 31	4	13	16	4	20	7	34	4.9	12
44	...do.....	Aug. 16	Aug. 16	Aug. 23	5	1	5	7	12	1	3	3.0	3
45	Aug. 13	Aug. 17	Aug. 23	Aug. 26	4	7	10	3	13	4	7	1.8	3
46	...do.....	...do.....	Sept. 1	Sept. 2	4	16	19	1	20	10	63	6.3	15
47	...do.....	Aug. 18	Aug. 31	Sept. 3	5	14	18	3	21	13	170	13.1	56
48	...do.....	...do.....	Aug. 18	Aug. 22	5	1	5	4	9	1	3	3.0	3
49	...do.....	Aug. 19	Aug. 24	Aug. 26	6	6	11	2	13	4	69	17.3	62
50	...do.....	...do.....	Aug. 29	Aug. 29	6	11	16	0	16	9	158	17.6	63
51	...do.....	Aug. 22	Aug. 27	...do.....	9	6	14	2	16	3	24	8.0	11
52	...do.....	...do.....	Aug. 29	Sept. 1	9	8	16	3	19	3	20	6.7	10
53	...do.....	Aug. 23	Sept. 2	Sept. 8	10	11	20	6	26	8	45	5.6	19
54	...do.....	Aug. 24	Sept. 1	Sept. 2	11	9	19	1	20	4	7	1.8	2
55	...do.....	Aug. 29	Sept. 2	Sept. 3	16	5	20	1	21	4	16	4.0	6
56	...do.....	Aug. 30	Aug. 30	Aug. 31	17	1	17	1	18	1	4	4.0	4
57	...do.....	Aug. 19	Aug. 23	Aug. 27	6	5	10	4	14	4	63	15.8	50
58	...do.....	Aug. 20	Aug. 20	...do.....	7	1	7	7	14	1	5	5.0	5
59	Aug. 15	Aug. 18	Aug. 22	Aug. 26	3	5	7	4	11	5	120	24.0	37
60	...do.....	...do.....	...do.....	...do.....	3	5	7	4	11	5	90	18.0	28
61	...do.....	...do.....	Aug. 24	Aug. 31	3	7	9	7	16	3	9	3.0	7
62	...do.....	Aug. 19	Aug. 28	Aug. 29	4	10	13	1	14	9	101	11.2	39
63	...do.....	Aug. 20	Aug. 20	Aug. 22	5	1	5	2	7	1	13	13.0	13
64	...do.....	...do.....	Aug. 27	Sept. 1	5	8	12	5	17	6	30	5.0	9
65	...do.....	Aug. 23	Aug. 24	...do.....	8	2	9	8	17	2	6	3.0	5
66	Aug. 19	Aug. 22	Aug. 25	Aug. 27	3	4	6	2	8	3	29	9.7	24
67	...do.....	...do.....	Aug. 26	...do.....	3	5	7	1	8	4	123	30.8	80
68	...do.....	...do.....	Aug. 23	Aug. 29	3	2	4	6	10	2	17	8.5	16
69	...do.....	...do.....	Sept. 4	Sept. 5	3	13	16	1	17	10	110	11.0	41

Table LXXIV.—*Oviposition by individual codling moths of the first brood, Grand Junction, Colo., 1915*—Continued.

Pair No.	Date of—				Period (in days).				Total length of life of female moth.	Number of days on which oviposition occurred.	Total number of eggs deposited.	Average number of eggs per oviposition.	Maximum number of eggs deposited in one day.
	Emergence of moths.	First eviposition.	Last oviposition.	Death of female moth.	Before eviposition.	Of oviposition.	From date of emergence to last oviposition.	Of life of female after oviposition.	*Days.*				
70	Aug. 19	Aug. 22	Aug. 30	Aug. 31	3	9	11	1	12	8	82	10. 3	50
71	...do.....	...do.....	Aug. 25	...do.....	3	4	6	6	12	4	83	20. 8	46
72	...do.....	Aug. 23	Aug. 29	Sept. 1	4	7	10	3	13	4	27	6. 8	12
73	...do.....	...do.....	Aug. 30	Aug. 31	4	8	11	1	12	6	55	9. 2	19
74	...do.....	Aug. 25	Sept. 1	Sept. 2	6	8	13	1	14	3	19	6. 3	9
75	...do.....	...do.....	Aug. 29	Sept. 1	6	5	10	3	13	5	32	6. 4	9
76	...do.....	Aug. 26	...do.....	Aug. 31	7	4	10	2	12	3	18	6. 0	11
77	...do.....	...do.....	...do.....	Sept. 1	7	4	10	3	13	2	12	6. 0	10
78	...do.....	Aug. 27	Sept. 7	Sept. 10	8	12	19	3	22	8	24	3. 0	5
79	...do.....	Aug. 28	...do.....	Sept. 8	9	11	19	1	20	6	30	5. 0	10
80	...do.....	Aug. 29	Aug. 31	Sept. 2	10	3	12	2	14	2	8	4. 0	5
81	...do.....	Sept. 1	Sept. 1	Sept. 8	13	1	13	7	20	1	9	9. 0	9
82	...do.....	...do.....	Sept. 9	Sept. 12	13	9	21	3	24	4	13	3. 3	7
83	...do.....	Sept. 2	Sept. 2	Sept. 5	14	1	14	3	17	1	4	4. 0	4
	Total.	....	....	....	....	....	......	......	......	347	3, 762	......	......

Summary.

	Average.	Maximum.	Minimum.
Number of days from emergence to first oviposition........	4. 90	17	1
Number of days from emergence to last oviposition........	9. 66	21	1
Number of days in period during which female was depositing eggs..	5. 75	16	1
Number of days on which oviposition occurred.............	4. 18	13	1
Number of days female moth lived after last oviposition..	3. 12	10	0
Total length of life of female moth in days..................	12. 80	26	4
Number of eggs deposited by one female moth.............	45. 33	185	1
Number of eggs deposited by one female moth in one day.	10. 84	80	0

In Table LXXV it will be noted that 14 moths have an oviposition record of 100 or more eggs, one having laid 185 eggs, two over 150 eggs, one over 125, and ten between 100 and 125 eggs.

Table LXXV.—*Oviposition by individual codling moths of the first brood, Grand Junction, Colo., 1915; data taken from Table LXXIV.*

Number of eggs deposited by individual moths.			
100 to 125	125 to 150	150 to 175	175 to 200
101	136	158	185
103		170	
103			
110			
115			
118			
120			
121			
121			
123			

Moths of the first brood, 1916.—The study of the number of eggs deposited by moths of the first brood was continued in 1916 on a more extensive scale than during the preceding year. The methods employed, however, were identical in all respects. The data herewith given were obtained by recording daily the number of eggs laid by 201 female moths, beginning with moths that emerged July 11 and ending with moths that issued August 22. As will be seen in Table LXXVI, these 201 individuals deposited a total of 17,225 eggs, or an average of 85.70 eggs per female.

TABLE LXXVI.—*Oviposition by individual codling moths of the first brood, Grand Junction, Colo., 1916.*

Pair No.	Date of—				Period (in days).				Total length of life of female moth.	Number of days on which oviposition occurred.	Total number of eggs deposited.	Average number of eggs per oviposition.	Maximum number of eggs deposited in one day.
	Emergence of moths.	First oviposition.	Last oviposition.	Death of female moth.	Before oviposition.	Of oviposition.	From date of emergence to last oviposition.	Of life of female after oviposition.	Days.				
1	July 11	July 13	July 22	July 23	2	10	11	1	12	9	229	25.4	57
2	...do....	July 14	July 21	July 22	3	8	10	1	11	5	109	21.8	38
3	...do.....	July 19	July 25	July 27	8	7	14	2	16	5	15	3.0	6
4	...do.....	...do.....	July 23	July 28	8	5	12	5	17	5	48	9.6	29
5	...do.....	....	....	July 16	....	....	......	......	5	....	0	......	......
6	...do.....	July 20	July 20	July 23	9	1	9	3	12	1	3	3.0	3
7	July 12	July 17	July 23	July 26	5	7	11	3	14	7	185	26.4	67
8	...do.....	July 15	...do.....	July 30	3	9	11	7	18	8	192	24.0	45
9	...do.....	July 14	July 14	July 24	2	1	2	10	12	1	39	39.0	39
10	...do.....	July 21	July 21	July 26	9	1	9	5	14	1	6	6.0	6
11	...do.....	July 19	July 23	...do.....	7	5	11	3	14	3	5	1.7	3
12	...do.....	....	....	(1)	....	....	......	......	......	....	0	......	......
13	July 13	July 23	July 29	July 30	10	7	16	1	17	5	12	2.4	6
14	...do.....	July 18	July 26	July 28	5	9	13	2	15	9	186	20.7	66
15	...do.....	...do.....	July 25	...do.....	5	8	12	3	15	8	55	6.9	27
16	...do.....	July 15	July 27	July 27	2	13	14	0	14	13	199	15.3	64
17	...do.....	...do.....	July 20	July 21	2	6	7	1	8	6	107	17.8	36
18	...do.....	...do.....	July 21	(1)	2	7	8	......	......	7	185	26.4	54
19	...do.....	July 16	...do.....	July 25	3	6	8	4	12	5	127	25.4	54
20	...do.....	...do.....	July 18	...do.....	3	3	5	7	12	3	146	48.7	77
21	...do.....	....	....	Aug. 5	....	....	......	......	23	....	0	......	......
22	...do.....	July 29	July 29	July 29	16	1	16	0	16	1	1	1.0	1
23	July 14	July 16	July 21	July 22	2	6	7	1	8	6	159	26.5	48
24	...do.....	July 22	July 29	July 30	8	8	15	1	6	4	9	2.3	4
25	...do.....	July 23	...do.....	...do.....	9	7	15	1	6	5	46	9.2	21
26	...do.....	July 16	July 31	Aug. 1	2	16	17	1	18	8	89	11.1	45
27	...do.....	...do.....	July 29	July 29	2	14	15	0	15	11	69	6.3	10
28	...do.....	July 18	...do.....	...do.....	4	12	15	0	15	10	245	24.5	74
29	...do.....	July 16	Aug. 1	Aug. 2	2	17	18	1	19	10	58	5.8	22
30	...do.....	....	....	July 17	....	....	......	......	3	....	0	......	......
31	...do.....	....	....	July 25	....	....	......	......	11	....	0	......	......
32	July 15	July 17	July 22	July 30	2	6	7	8	15	5	99	19.8	40
33	...do.....	July 20	July 20	July 20	5	1	5	0	5	1	8	8.0	8
34	...do.....	July 17	July 27	July 28	2	11	12	1	13	11	266	24.2	78
35	...do.....	July 18	July 30	July 30	3	13	15	0	15	13	168	12.9	48
36	...do.....	July 19	Aug. 3	Aug. 4	4	16	19	1	20	7	21	3.0	8
37	...do.....	July 31	Aug. 5	Aug. 7	16	6	21	2	23	6	20	3.3	8
38	...do.....	July 18	July 30	July 31	3	13	15	1	16	11	207	18.8	51
39	...do.....	July 22	Aug. 5	Aug. 6	7	15	21	1	22	13	77	5.9	18
40	...do.....	....	....	July 17	....	....	......	......	2	....	0	......	......
41	...do.....	July 24	Aug. 7	Aug. 9	9	15	23	2	25	3	3	1.0	1
42	July 16	July 18	July 29	Aug. 1	2	12	13	3	16	5	120	24.0	76
43	...do.....	...do.....	July 24	July 30	2	7	8	6	14	4	7	1.8	3
44	...do.....	July 22	Aug. 3	Aug. 3	6	13	18	0	18	13	271	20.8	54
45	...do.....	July 18	July 23	July 25	2	6	7	2	9	6	151	25.2	87
46	...do.....	July 23	July 30	Aug. 1	7	8	14	2	16	7	113	16.1	45
47	...do.....	July 22	Aug. 1	...do.....	6	11	16	0	16	5	8	1.6	3
48	...do.....	July 20	Aug. 15	Aug. 16	4	27	30	1	31	14	35	2.5	6

[1] Date of death unknown.

TABLE LXXVI.—*Oviposition by individual codling moths of the first brood, Grand Junction, Colo., 1916*—Continued.

Pair No.	Date of—				Period (in days).				Total length of life of female moth.	Number of days on which oviposition occurred.	Total number of eggs deposited.	Average number of eggs per oviposition.	Maximum number of eggs deposited in one day.
	Emergence of moths.	First oviposition.	Last oviposition.	Death of female moth.	Before oviposition.	Of oviposition.	From date of emergence to last oviposition.	Of life of female after oviposition.					
									Days.				
49	July 16	July 19	July 31	Aug. 1	3	13	15	1	16	11	119	10.8	31
50	...do.....	....	....	July 29	....	....	......	......	13	....	0	......	......
51	July 17	July 24	July 31	July 1	7	8	14	1	15	8	67	8.4	20
52	...do.....	July 23	Aug. 2	July 2	6	11	16	0	16	10	128	12.8	71
53	...do.....	July 20	July 30	July 1	3	10	13	2	15	8	95	11.9	31
54	...do.....	July 19	July 28	July 29	2	10	11	1	12	10	213	21.3	47
55	...do.....	July 22	Aug. 2	Aug. 2	5	12	16	0	16	10	175	17.5	81
56	...do.....	July 19	July 27	July 30	2	9	10	3	13	9	258	28.7	81
57	...do.....	July 22	Aug. 4	Aug. 4	5	14	18	0	18	12	90	7.5	16
58	...do.....	July 21	July 31	July 31	4	11	14	0	14	11	195	17.7	51
59	...do.....	July 19	July 28	July 30	2	10	11	2	13	8	121	15.1	61
60	...do.....	July 23	July 27	Aug. 1	6	5	10	5	15	2	2	1.0	1
61	July 18	July 20	July 30	Aug. 2	2	11	12	3	15	11	215	19.5	62
62	...do.....	...do.....	...do.....	July 31	2	11	12	1	13	10	126	12.6	28
63	...do.....	July 22	Aug. 6	Aug. 7	4	16	19	1	20	9	101	1.1	56
64	...do.....	...do.....	July 31	Aug. 2	4	10	13	2	15	9	139	15.4	58
65	...do.....	July 20	July 29	July 29	2	10	11	0	11	10	236	23.6	69
66	...do.....	July 22	July 31	Aug. 2	4	10	13	2	15	9	183	20.3	69
67	...do.....	...do.....	Aug. 1	Aug. 4	4	11	14	3	17	4	5	1.3	2
68	...do.....	...do.....	July 22	July 26	4	1	4	4	8	1	2	2.0	2
69	...do.....	July 26	July 26	Aug. 2	8	1	8	7	15	1	1	1.0	1
70	July 19	July 21	July 31	...do.....	2	11	12	2	14	5	22	4.4	8
71	...do.....	July 28	Aug. 6	Aug. 7	9	10	18	1	19	8	56	7.0	20
72	...do.....	July 22	July 31	Aug. 1	3	10	12	1	13	10	165	16.5	37
73	...do.....	July 28	Aug. 2	Aug. 5	9	6	14	3	17	4	20	5.0	7
74	...do.....	July 24	July 30	July 30	5	7	11	0	11	7	126	18.0	27
75	...do.....	July 28	Aug. 3	Aug. 4	9	7	15	1	16	6	98	16.3	38
76	...do.....	....	....	July 29	....	....	......	......	10	....	0	......	......
77	...do.....	Aug. 2	Aug. 2	Aug. 9	14	1	14	7	21	1	2	2.0	2
78	...do.....	....	....	Aug. 3	....	....	......	......	15	....	0	......	......
79	July 20	July 24	Aug. 5	Aug. 6	4	13	16	1	17	9	223	24.8	111
80	...do.....	July 25	Aug. 9	Aug. 14	5	16	20	5	25	9	20	2.2	5
81	...do.....	July 24	Aug. 4	Aug. 4	4	12	15	0	15	10	55	5.5	15
82	...do.....	July 22	Aug. 5	Aug. 7	2	15	16	2	18	10	200	20.0	109
83	...do.....	July 25	July 30	July 30	5	6	10	0	10	6	165	27.5	44
84	...do.....	July 23	...do.....	Aug. 1	3	8	10	2	12	8	252	31.5	89
85	...do.....	July 22	Aug. 6	Aug. 9	2	16	17	3	20	9	29	3.2	9
86	July 21	...do.....	July 29	July 30	1	8	8	1	9	6	102	17.0	47
87	...do.....	July 23	July 30	Aug. 5	2	8	9	6	15	6	91	15.2	40
88	...do.....	July 31	Aug. 8	Aug. 9	10	9	18	1	19	9	181	20.1	50
89	...do.....	July 25	Aug. 17	Aug. 18	4	24	27	1	28	20	136	6.8	22
90	...do.....	....	....	July 28	....	....	......	......	7	....	0	......	......
91	Aug. 5	Aug. 7	Aug. 24	Aug. 25	2	18	19	1	20	17	316	18.6	112
92	Aug. 6	...do.....	Aug. 17	Aug. 18	1	11	11	1	12	11	240	21.8	52
93	...do.....	Aug. 14	Aug. 28	Aug. 29	8	15	22	1	23	12	249	20.8	106
94	...do.....	Aug. 11	...do.....	Sept. 1	5	18	22	4	26	7	13	1.9	3
95	...do.....	Aug. 14	Aug. 21	Aug. 23	8	8	15	2	17	8	175	21.9	69
96	...do.....	...do.....	Aug. 17	...do.....	8	4	11	6	17	3	21	7.0	19
97	...do.....	Aug. 8	Aug. 14	Aug. 20	2	7	8	6	14	6	88	14.7	47
98	...do.....	....	....	Aug. 23	....	....	......	......	17	....	0	......	......
99	...do.....	Aug. 8	Aug. 19	Aug. 19	2	12	13	0	13	2	2	1.0	1
100	...do.....	....	....	Aug. 13	....	....	......	......	7	....	0	......	......
101	...do.....	Aug. 19	Aug. 19	Sept. 4	13	1	13	16	29	1	2	2.0	2
102	Aug. 8	Aug. 10	Aug. 27	(1)	2	18	19	......	......	8	56	7.0	18
103	...do.....	Aug. 12	Aug. 23	Aug. 24	4	12	15	1	16	11	39	3.5	12
104	...do.....	Aug. 11	Aug. 17	Aug. 20	3	7	9	3	12	7	158	22.6	49
105	...do.....	Aug. 15	Aug. 22	Aug. 24	7	8	14	2	16	5	8	1.6	2
106	...do.....	Aug. 14	Aug. 16	Aug. 18	6	3	8	2	10	3	133	44.3	115
107	...do.....	Aug. 25	Sept. 4	Sept. 5	17	11	27	1	28	2	3	1.5	2
108	...do.....	Aug. 12	Aug. 18	Aug. 21	4	7	10	3	13	2	4	2.0	3
109	Aug. 9	Aug. 17	Aug. 19	Aug. 22	8	3	10	3	13	3	7	2.3	4
110	...do.....	...do.....	...do	Aug. 19	8	3	10	0	10	3	20	6.7	10
111	...do.....	Aug. 18	Aug. 31	(1)	9	14	22	......	......	10	29	2.9	6
112	...do.....	Aug. 11	Sept. 5	Sept. 11	2	26	27	6	33	16	74	4.6	17
113	...do.....	...do.....	Aug. 29	Aug. 30	2	19	20	1	21	18	227	12.6	25
114	...do.....	...do.....	Aug. 23	Aug. 24	2	13	14	1	15	6	22	3.7	13

[1] Date of death unknown.

TABLE LXXVI.—*Oviposition by individual codling moths of the first brood, Grand Junction, Colo., 1916*—Continued.

Pair No.	Date of—				Period (in days).				Total length of life of female moth.	Number of days on which oviposition occurred.	Total number of eggs deposited.	Average number of eggs per oviposition.	Maximum number of eggs deposited in one day.
	Emergence of moths.	First oviposition.	Last oviposition.	Death of female moth.	Before oviposition.	Of oviposition.	From date of emergence to last oviposition.	Of life of female after oviposition.					
									Days.				
115	Aug. 9	Aug. 14	Aug. 28	Sept. 2	5	15	19	5	24	14	116	8.3	22
116	...do.....	Aug. 11	Aug. 30	Aug. 31	2	20	21	1	22	19	88	4.6	9
117	...do.....	Aug. 16	Aug. 16	Aug. 24	7	1	7	8	15	1	1	1.0	1
118	...do.....	....	....	Aug. 22	....	....	......	......	13	......	0	......	......
119	Aug. 10	Aug. 16	Aug. 28	Aug. 29	6	13	18	1	19	11	188	17.1	54
120	...do.....	Aug. 12	Aug. 25	Aug. 25	2	14	15	0	15	10	112	11.2	44
121	...do.....	Aug. 15	Aug. 23	Aug. 29	5	9	13	6	19	8	142	17.8	43
122	...do.....	Aug. 23	Aug. 31	Sept. 2	13	9	21	2	23	6	50	8.3	31
123	...do.....	Aug. 18	Aug. 19	Sept. 3	8	2	9	15	24	2	3	2.5	2
124	...do.....	....	....	Aug. 26	....	....	......	......	16	......	0	......	......
125	...do.....	....	....	Aug. 25	....	....	......	......	15	......	0	......	......
126	...do.....	Aug. 17	Aug. 24	Aug. 30	7	8	14	6	20	3	4	1.3	2
127	...do.....	Aug. 25	Aug. 31	(1)	15	7	21	......	......	4	7	1.8	3
128	...do.....	Aug. 18	Aug. 19	Aug. 30	8	2	9	11	20	2	6	3.0	4
129	Aug. 11	Aug. 12	Aug. 27	Aug. 27	1	16	16	0	16	13	133	10.2	51
130	...do.....	Aug. 15	Sept. 8	Sept. 11	4	25	28	3	31	24	210	8.8	37
131	...do.....	Aug. 19	Aug. 29	Aug. 31	8	11	18	2	20	8	27	3.4	10
132	...do.....	Aug. 17	Aug. 25	Aug. 26	6	9	14	1	15	6	65	10.8	22
133	...do.....	...do.....	Sept. 13	Sept. 13	6	28	33	0	33	24	139	5.8	15
134	...do.....	Sept. 2	Sept. 11	...do....	22	10	31	2	33	5	6	1.2	2
135	...do.....	Aug. 14	Sept. 3	Sept. 6	3	21	23	3	26	18	251	13.9	39
136	...do.....	Aug. 15	Sept. 9	Sept. 13	4	26	29	4	33	22	116	5.3	13
137	...do.....	Aug. 14	Aug. 14	Aug. 22	3	1	3	8	11	1	2	2.0	2
138	...do.....	....	....	Aug. 23	....	....	......	......	12	......	0	......	......
139	Aug. 13	Aug. 16	Aug. 21	...do....	3	6	8	2	10	3	82	27.3	49
140	...do.....	Aug. 15	Aug. 28	(1)	2	14	15	......	......	12	213	17.8	34
141	...do.....	...do.....	Aug. 24	Aug. 26	2	10	11	2	13	9	144	16.0	34
142	...do.....	Aug. 16	Aug. 29	Aug. 30	3	14	16	1	17	10	120	12.0	33
143	...do.....	Aug. 18	Aug. 26	Aug. 31	5	9	13	5	18	7	103	14.7	72
144	...do.....	Aug. 15	Aug. 18	Aug. 19	2	4	5	1	6	4	61	15.3	33
145	...do.....	Aug. 18	Aug. 25	Aug. 25	5	8	12	0	12	7	163	23.3	41
146	...do.....	Aug. 23	Aug. 23	Aug. 24	10	1	10	1	11	1	2	2.0	2
147	...do.....	Aug. 28	Aug. 28	Sept. 8	15	1	15	11	26	1	2	2.0	2
148	...do.....	Aug. 17	Aug. 19	Aug. 24	4	3	16	5	11	2	2	1.0	1
149	Aug. 14	Aug. 15	Sept. 3	Sept. 4	1	20	20	1	21	9	28	3.1	8
150	...do.....	Aug. 18	Aug. 25	Aug. 26	4	8	11	1	12	3	10	3.3	5
151	...do.....	Aug. 22	Aug. 27	Aug. 28	8	6	13	1	14	5	43	8.6	18
152	...do.....	Aug. 17	...do....	...do....	3	11	13	1	14	11	227	20.6	71
153	...do.....	Aug. 16	Sept. 6	Sept. 11	2	22	23	5	28	21	308	14.7	52
154	...do.....	Aug. 17	Aug. 27	Sept. 3	3	11	13	7	20	7	80	11.4	41
155	...do.....	Aug. 18	Aug. 31	(1)	4	14	17	......	......	13	223	17.2	45
156	...do.....	Aug. 21	Sept. 1	Sept. 2	7	12	18	1	19	10	99	9.9	20
157	...do.....	Aug. 19	Aug. 19	Aug. 20	5	1	5	1	6	1	3	3.0	3
158	...do....	....	....	Aug. 30	....	....	......	......	16	......	0	......	......
159	Aug. 15	Aug. 17	Aug. 31	Sept. 2	2	15	16	2	18	15	252	1.7	41
160	...do.....	Aug. 18	Aug. 21	Aug. 25	3	4	6	4	10	4	33	8.3	19
161	...do.....	...do.....	Aug. 29	(1)	3	12	14	......	......	10	186	18.6	59
162	...do.....	Aug. 23	Sept. 3	Sept. 5	8	12	19	2	21	7	17	2.4	8
163	...do.....	Aug. 18	Aug. 18	Aug. 21	3	1	3	3	6	1	8	8.0	8
164	...do.....	...do....	Aug. 20	Aug. 26	3	3	5	6	11	3	21	7.0	10
165	...do.....	Aug. 17	Aug. 28	Aug. 29	2	12	13	1	14	11	221	2.0	60
166	...do.....	Aug. 19	Aug. 31	Sept. 1	4	13	16	1	17	4	6	1.5	3
167	...do.....	Aug. 24	Aug. 29	Sept. 2	9	6	14	4	18	3	6	2.0	3
168	...do.....	Aug. 21	Aug. 21	Sept. 1	6	1	6	11	17	1	1	1.0	1
169	Aug. 16	Aug. 27	Sept. 1	Sept. 6	11	6	16	5	21	5	10	2.0	4
170	...do.....	Aug. 26	Sept. 3	Sept. 4	10	9	18	1	19	5	16	3.2	7
171	...do.....	Aug. 18	Aug. 24	Aug. 28	2	7	8	4	12	4	134	33.5	89
172	...do.....	Aug. 27	Aug. 28	Sept. 2	11	2	12	5	17	2	2	1.0	1
173	...do.....	Aug. 30	Aug. 30	Sept. 1	14	1	14	2	16	1	1	1.0	1
174	...do.....	Aug. 26	Aug. 28	...do.....	10	3	12	4	16	2	4	2.0	3
175	...do.....	....	....	Aug. 24	....	....	......	......	8	......	0	......	......
176	Aug. 18	Aug. 21	Aug. 31	(1)	3	11	13	......	......	11	277	25.2	59
177	...do.....	Aug. 20	Aug. 28	Aug. 29	2	9	10	1	11	9	168	18.7	68
178	...do.....	Aug. 25	Aug. 29	Sept. 10	7	5	11	12	23	2	2	1.0	1
179	...do.....	Aug. 20	...do....	Sept. 1	2	10	11	3	14	9	71	7.9	18
180	...do.....	....	....	Sept. 4	....	....	......	......	17	......	0	......	......
181	...do.....	Aug. 24	Aug. 31	Sept. 1	6	8	13	1	14	3	3	1.0	1
182	...do.....	Aug. 25	Aug. 27	Sept. 2	7	3	9	6	15	2	3	1.5	2

[1] Date of death unknown.

TABLE LXXVI.—*Oviposition by individual codling moths of the first brood, Grand Junction, Colo., 1916*—Continued.

Pair No.	Date of—				Period (in days).				Total length of life of female moth.	Number of days on which oviposition occurred.	Total number of eggs deposited.	Average number of eggs per oviposition.	Maximum number of eggs deposited in one day.
	Emergence of moths.	First oviposition.	Last oviposition.	Death of female moth.	Before oviposition.	Of oviposition.	From date of emergence to last oviposition.	Of life of female after oviposition.	Days.				
183	Aug. 21	Aug. 24	Sept. 9	Sept. 9	3	17	19	0	19	14	247	17.6	46
184	...do.....	...do.....	Sept. 14	(1)	3	22	24	......	......	20	135	6.8	20
185	...do.....	...do.....	Sept. 8	Sept. 10	3	16	18	2	20	14	309	22.1	76
186	...do.....	Aug. 26	Sept. 3	Sept. 12	5	9	13	9	22	6	13	2.2	4
187	...do.....	Aug. 24	Sept. 2	Sept. 3	3	10	12	1	13	7	80	11.3	28
188	...do.....	...do.....	Sept. 4	Sept. 6	3	12	14	2	16	5	12	2.4	4
189	...do.....	Aug. 26	Sept. 17	Sept. 18	5	23	27	1	28	16	50	3.1	7
190	...do.....	Aug. 25	Sept. 8	Sept. 11	4	15	18	3	21	8	21	2.6	5
191	...do.....	Aug. 22	Aug. 29	Sept. 5	1	8	8	7	15	7	87	12.4	29
192	Aug. 22	Aug. 24	Sept. 24	Sept. 25	2	32	33	1	34	31	203	6.5	17
193	...do.....	Aug. 31	Sept. 15	Sept. 18	9	16	24	3	27	11	33	3.0	13
194	...do.....	Aug. 26	Sept. 25	Sept. 30	4	31	34	5	39	19	47	2.5	9
195	...do	Aug. 30	Sept. 13	Sept. 17	8	15	22	4	26	10	42	4.2	14
196	...do	Aug. 25	Aug. 30	Aug. 31	3	6	8	1	9	6	157	26.2	63
197	...do	Sept. 2	Sept. 11	Sept. 14	11	10	20	3	23	7	118	16.9	55
198	...do	Aug. 28	Sept. 22	Sept. 25	6	26	31	3	34	21	182	8.7	64
199	...do.....	Aug. 27	Sept. 12	Sept. 13	5	17	21	1	22	12	29	2.4	5
200	...do.....	Aug. 24	Sept. 1	Sept. 5	2	9	10	4	14	5	9	1.8	3
201	...do.....	Aug. 28	...do	...do	6	5	10	4	14	4	32	8.0	8
	Total	....	....	....	....	....	......	......	......	1,467	17,225	......	......

[1] Date of death unknown.

SUMMARY.

	Average.	Maximum.	Minimum.
Number of days from emergence to first oviposition	5.19	22	1
Number of days from emergence to last oviposition.	14.47	34	2
Number of days in period during which female was depositing eggs	10.26	32	1
Number of days on which oviposition occurred....	8.06	31	1
Number of days female moth lived after last oviposition	2.80	16	0
Total length of life of female moth in days..........	16.42	39	3
Number of eggs deposited by one female moth.....	85.70	316	0
Number of eggs deposited by one female moth in one day	11.74	115	0

It will be noted also in this table that the female moth of pair No. 91 deposited 316 eggs, which is, so far as the writers are aware, the highest number of eggs ever recorded from one individual codling moth. This moth was seen in copula on August 7, or two days after issuance, and two days later, August 9, deposited 112 eggs, or over one-third of her total. Another moth, of pair No. 106, emerged August 8, but did not deposit an egg until August 14, on this date laying 115 eggs. This is believed to be the highest recorded number of eggs deposited in one day by an individual codling moth. In addition to this moth several other females deposited over 100 eggs in one day, the average being 11.74.

A comparison of Tables XLII and LXXVI will show that the average number of eggs per female was greater in 1916, but that, as in 1915, the period of oviposition was shortened somewhat and that it was also delayed where the pairs were confined alone in individual cages. However, in 1916, the female lived for an average of 12.20 days when confined with other moths in a large battery-jar cage, as shown in Table XLIII, compared with 16.42 days when caged individually. Other important phases of the individual oviposition studies of 1916 are given in detail in Table LXXVI.

An abbreviated table giving the data for all of the moths that deposited 100 or more eggs is given herewith. (See Table LXXVII.) Referring to this table, it will be noted that 3 moths deposited over 300 eggs each, 1 moth deposited between 275 and 300 eggs, 6 moths between 250 and 275 eggs, 8 moths between 225 and 250 eggs, 10 moths between 200 and 225 eggs, 13 moths between 175 and 200 eggs, 9 moths between 150 and 175 eggs, 14 moths between 125 and 150 eggs, and 14 moths between 100 and 125 eggs.

TABLE LXXVII.—*Oviposition by individual codling moths of the first brood, Grand Junction, Colo., 1916. Data taken from Table LXXVI.*

Number of eggs deposited.								
100 to 125	125 to 150	150 to 175	175 to 200	200 to 225	225 to 250	250 to 275	275 to 300	300 to 325
101	126	151	175	200	227	251	277	308
102	126	157	175	203	227	252		309
103	127	158	181	207	229	252		316
107	128	159	182	210	236	258		
109	133	163	183	213	240	266		
112	133	165	185	213	245	271		
113	134	165	185	215	247			
116	135	168	186	221	249			
116	136	168	186	223				
118	139		188	223				
119	139		192					
120	142		195					
120	144		199					
121	146							

DEPOSITION OF INFERTILE EGGS.

On July 15, 1915, 30 female moths of the first brood which emerged on this day were confined alone in a cage to find the number of eggs deposited when male moths were not present. The results are given in Table LXXVIII, in which it will be seen that a total of 232 eggs were deposited, or an average of 7.40 eggs per moth.

TABLE LXXVIII.—*Deposition of infertile codling moth eggs, Grand Junction, Colo., 1915 (30 female moths emerged July 15).*

Number of eggs deposited.	Date of deposition.	Number of dead moths.	Date of death of moths.
2	July 18	1	July 21
3	19	3	23
30	20	5	24
16	21	1	25
8	22	3	26
42	23	1	27
31	24	2	28
4	26	1	29
40	27	3	30
6	28	2	31
12	29	2	Aug. 1
35	30	1	2
3	Aug. 1	3	3
		1	4
		1	5
232	....	30	....

TIME REQUIRED FOR CODLING-MOTH LARVA TO LEAVE THE EGG.

The following notes were made July 30, 1915, on the time required for a codling-moth larva to leave the egg.

Egg No. 1.—At 1.10 p. m. there was a small rent in the chorion and at 1.50 p. m. the larva had completely left the eggshell.

Egg No. 2.—At 1.15 p. m. the larva had cut a small opening in the eggshell, and had hatched by 1.23 p. m.

Egg No. 3.—At 1.20 p. m. the larva was found moving its body and mandibles intermittently until 2.03 p. m. It hatched at 2.06 p. m.

Egg No. 4.—The eggshell was found slightly opened at 2.09 p. m. The larva hatched at 2.13 p. m.

Egg No. 5.—This egg was slightly open at 2.18 p. m., and although the larva made repeated attempts to extricate itself it did not accomplish its task until 2.55 p. m.

As previously stated, the codling-moth larva normally tears a small opening in the eggshell by means of its mandibles and then passes out of the shell head foremost.

LARVÆ THAT FAIL TO EXTRICATE THEMSELVES FROM THE CHORION.

On several occasions larvæ were found dead after having partially extricated themselves from the chorion. In these instances it was noted that the anal end was protruding through the cut in the eggshell, but that the larva was held from freeing itself on account of the cervical shield and head, which were too large to pass through the opening. Normally, as previously mentioned, the larva tears a slit in the eggshell by means of its mandibles and then passes head first through the rent.

HABITS OF NEWLY HATCHED LARVÆ.

The natural instinct of newly-hatched insect larvæ is to seek suitable food on which to commence feeding. In the case of the codling moth the fruit of the apple and pear is the preferred food, but the larvæ will also attack the foliage and occasionally will burrow into the tips of tender twigs. The injury to the foliage is of little consequence, consisting of small holes through the lower epidermis, usually where the leaf is fleshy, as at the junction of the veins with the midrib.

The frequency and amount of foliage feeding depend mainly on the distance of the eggs from the fruit and the ease with which the larvæ find their ultimate object. Normally the early-season eggs are deposited upon the whorl of leaves about the fruit, while later in the year many eggs are laid directly on the fruit. It has been observed that some larvæ spend considerable time before they reach the fruit and that these satisfy their appetites on the foliage during the interim.

Upon reaching the fruit, the larvæ seek a place of entrance, as through the calyx, side, or stem. (See Pl. VI, A.) Some individuals crawl over the fruit for some little time before making an attack, while others proceed to enter with little hesitation. The larvæ will frequently take advantage of depressions or ruptures in the skin, as frost pits, hail marks, or injury from other causes.

The larvæ, in starting to feed, tear away the skin by means of their mandibles and cast most of it aside, consuming very little. They first work directly beneath the skin, forming a shallow excavation just large enough to accommodate them, and at the same time, plug their entrance with frass.

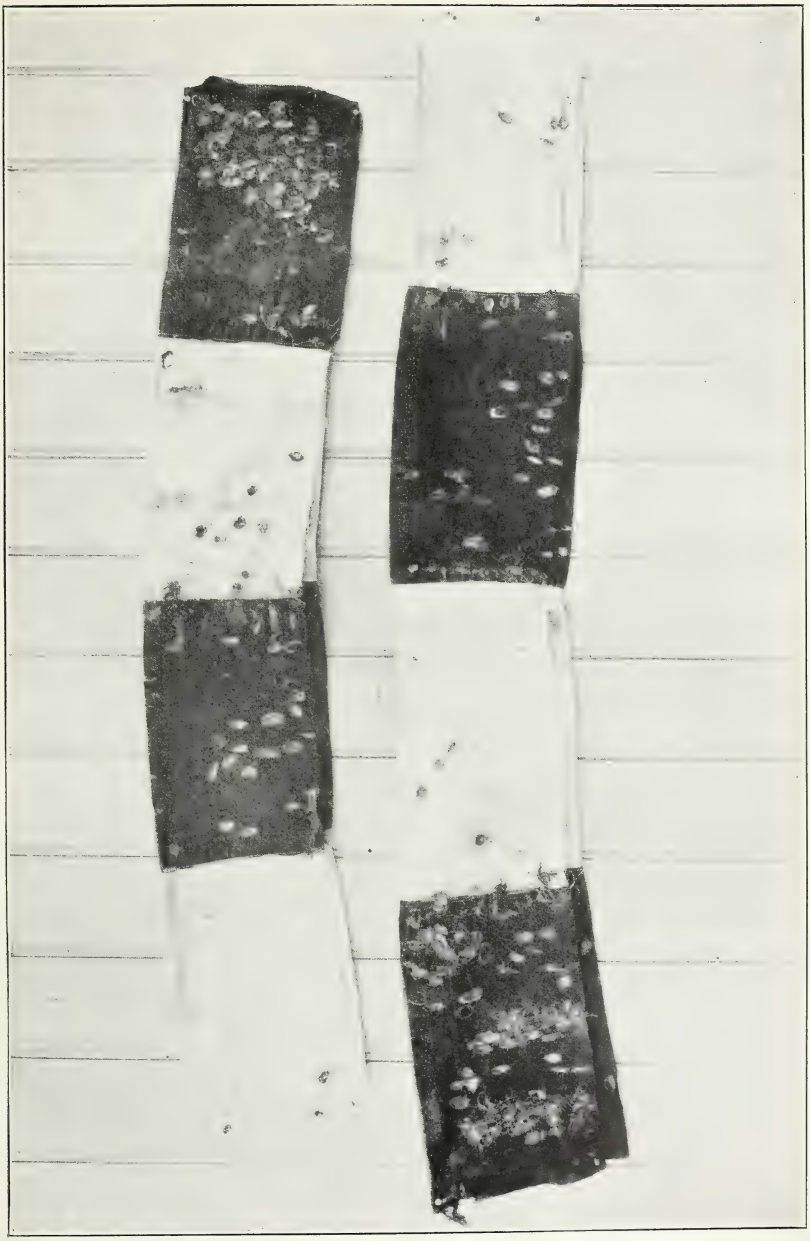
THE CODLING-MOTH "STING."

The so-called "sting" is caused by the larvæ that succumb to the poison before they are able to make more than the shallow excavation above referred to. They sometimes die from natural causes after having penetrated beneath the skin and occasionally they leave an entrance hole to start a new one.

CODLING-MOTH LARVÆ FEEDING ON PEAR TWIGS.

On June 24, 1915, an examination of a pear orchard was made to determine the cause of the browning of the leaves. At first sight the orchard appeared to be affected with pear blight, *Bacillus amylovorus* (Burrill) De Toni, but on closer inspection it was found that codling-moth larvæ were responsible for the injury. There was practically no fruit in the orchard, owing to the spring freezes, and, as a result, the larvæ burrowed into the terminal ends of the twigs to a

PLATE VII.



THE CODLING MOTH IN THE GRAND VALLEY OF COLORADO.

BLACK AND WHITE BANDS SHOWING THAT LARVÆ PREFER TO FORM COCOONS BENEATH THE BLACK CLOTH.

distance of about three-fourths inch. In many of the burrows no larvæ were found, they evidently having decided to leave after they had consumed most of the softer tissue of the new growth. The larvæ found were in either the third or fourth instars. An attempt was made to rear some of these larvæ in pear twigs, but this was unsuccessful. Two of the larvæ obtained from the pear twigs, however, were transferred to apples on the date collected, June 24, and from these two moths were reared, one moth issuing on July 19 and the other on July 20.

EXPERIMENTS WITH BLACK AND WHITE BANDS.

In fruit districts where the codling moth is abundant, spraying is frequently supplemented with banding. With the banding method a strip of cloth is placed around the trunk of the tree and the codling-moth larvæ that form cocoons beneath the cloth are destroyed at intervals of about 10 days throughout the season. The question has frequently been asked whether dark-colored bands are more attractive as a place of concealment than bands of a light color. To determine this, an experiment was made in 1916 in which were used bands of cloth folded to three thicknesses, each alternate quarter of which was black and white. (See Pl. VII.) The trunks of 10 trees were first thoroughly scraped and were then encircled with bands of this description on July 5. The segments of the bands were arranged so that the white and black quarters alternated with the four quarters of the trunk. Thus on 5 trees there was a black segment on the northeast side of the tree, while on the 5 remaining trees there was a white segment covering this quarter. The bands were first examined for larvæ on July 8 and every 3 days thereafter to August 19, inclusive. The results of this study are given in Table LXXIX, in which it will be seen that the codling-moth larva is strongly inclined, when the opportunity is present, to spin its cocoon beneath dark-colored cloth. Out of a total of 2,362 larvæ collected, 2,083, or 88.19 per cent, spun their cocoons beneath the black segments of the bands. A summary of this table is given in Table LXXX, which shows the number of larvæ collected under each segment. According to these figures, the codling-moth larvæ, with one exception, preferred the northern exposure of the tree trunk.

TABLE LXXIX.—*Experiments with black and white bands for the codling moth, Grand Junction, Colo., 1916.*

Tree No.	Color of band section and location on tree trunk.	Number of larvæ collected beneath band sections.															Total number of larvæ.	
		July 8.	July 11.	July 14.	July 17.	July 20.	July 23.	July 26.	July 29.	Aug. 1.	Aug. 4.	Aug. 7.	Aug. 10.	Aug. 13.	Aug. 16.	Aug. 19.	Black band section.	White band section.
1	Black, N. E.	4	3	9	18	20	36	22	14	7	12	6	6	6	2	3	168	......
	White, S. E.	0	2	0	0	0	2	4	1	0	3	0	0	0	0	0	....	12
	Black, S. W.	1	2	6	14	16	29	10	6	4	4	2	0	2	2	4	102	......
	White,N.W.	0	0	0	0	1	2	0	0	1	0	1	0	0	1	0	....	6
2	White, N. E.	1	1	1	1	3	2	1	0	0	0	1	0	1	0	0	....	12
	Black, S. E..	3	5	4	12	12	18	16	5	7	10	4	1	4	2	2	105	......
	White, S. W.	0	0	1	0	0	1	1	1	0	1	1	0	0	0	0	....	6
	Black, N.W.	6	9	12	14	19	14	15	7	4	6	2	7	5	7	3	130	......
3	Black, N.E..	2	3	5	6	7	12	8	2	6	3	10	4	5	5	7	85	......
	White, S. E.	0	0	0	0	1	3	3	1	0	0	0	0	2	0	1	....	11
	Black, S.W..	3	0	6	1	13	4	4	3	4	3	3	2	3	4	3	56	......
	White,N.W.	1	0	2	2	3	1	1	1	1	0	0	2	4	5	4	....	27
4	White, N. E.	2	2	0	0	1	0	0	0	0	1	1	0	1	1	1	....	10
	Black, S. E..	0	1	6	5	2	9	5	1	4	4	2	3	6	1	7	56	......
	White, S.W.	1	0	0	0	2	1	1	0	0	2	4	2	3	5	0	....	21
	Black, N.W.	10	12	10	7	21	15	10	11	14	7	7	9	2	2	7	144	......
5	Black, N.E..	5	7	7	2	3	15	7	8	5	8	6	6	1	2	0	82	......
	White, S. E.	1	1	0	0	0	1	2	0	1	4	0	0	1	1	1	....	13
	Black, S.W..	0	2	2	1	7	3	7	3	3	0	3	2	1	1	4	39	......
	White,N.W.	0	0	2	0	1	3	0	0	0	1	0	1	3	0	1	....	12
6	White, N. E.	0	0	2	0	4	2	5	0	2	3	6	0	1	0	0	....	25
	Black, S.E..	5	3	2	5	12	9	6	4	2	5	0	1	1	1	1	57	......
	White, S.W.	0	0	0	0	0	1	3	2	0	0	1	0	0	0	1	....	8
	Black, N.W.	21	11	20	12	27	26	25	5	7	15	4	5	4	3	2	187	......
7	Black, N.E..	3	1	7	5	8	10	11	8	17	4	6	13	4	9	3	109	......
	White, S.E..	1	0	1	0	0	0	0	2	1	1	1	0	3	1	0	....	11
	Black, S.W..	0	0	4	2	6	5	3	2	2	4	1	1	4	4	2	40	......
	White,N.W.	1	1	0	0	1	5	2	0	1	5	4	0	3	4	0	....	27
8	White, N. E.	0	0	1	0	0	0	0	1	0	1	0	0	0	1	2	....	6
	Black, S.E..	3	2	10	5	10	10	9	4	8	3	0	1	2	3	0	70	......
	White, S.W.	1	0	0	0	0	1	1	2	0	1	0	0	3	1	4	....	14
	Black, N.W.	6	11	21	11	20	21	27	4	7	9	8	3	6	13	4	171	......
9	Black, N.E..	3	3	11	9	20	24	15	14	14	7	9	15	7	7	8	166	......
	White, S.E..	0	0	0	2	1	6	4	0	3	3	7	6	4	4	1	....	41
	Black, S.W..	0	2	15	12	13	25	19	8	2	3	2	9	5	7	4	126	......
	White,N.W.	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	....	3
10	White, N. E.	0	0	1	1	1	0	2	1	0	0	0	0	2	0	0	....	8
	Black, S.E..	8	3	3	10	13	3	6	3	2	1	1	2	0	3	1	59	......
	White, S.W.	0	0	0	1	0	0	1	0	0	0	0	0	0	0	4	....	6
	Black, N.W.	10	9	11	16	13	17	19	5	3	4	7	6	2	5	4	131	......
	Total larvæ	102	97	182	174	281	337	275	129	132	139	110	107	101	107	89	2,083	279

TABLE LXXX.—*Experiments with black and white bands for the codling moth, Grand Junction, Colo., 1916; summary of Table LXXIX.*

Color of band section and location on tree trunk.	Total number of larvæ collected.	Per cent of total number of larvæ.	Color of band section and location on tree trunk.	Total number of larvæ collected.	Per cent of total number of larvæ.
Black, N. E.....	610	25.83	White, N. E....	61	2.58
Black, S. E.....	347	14.69	White, S. E.....	88	3.72
Black, S. W.....	363	15.37	White, S. W....	55	2.33
Black, N. W.....	763	32.30	White, N. W....	75	3.18
Total.......	2,083	88.19	Total.......	279	11.81

This experiment merely indicates that the codling-moth larva prefers a dark cocooning place. It should not be inferred that light-colored bands are of no value, since it is entirely possible that if the codling-moth larva has no better place to cocoon, it will be content to spin beneath bands of a light color. In orchard practice, burlap-cloth bands, folded to two or three thicknesses, are very satisfactory for banding purposes.

PERCENTAGE OF TRANSFORMING AND WINTERING LARVÆ.

Season of 1915.—By reference to Table LXXXI it will be seen that 432 larvæ, or 47.52 per cent, of the first-brood larvæ that were reared in the insectary, transformed in 1915 to form the second brood; the remainder, 477, or 52.48 per cent, wintered. Out of 1,858 larvæ of the second brood, 20, or 1.08 per cent, transformed to form a third brood and the remainder, 1,838 larvæ, or 98.92 per cent, wintered. As previously mentioned, in the Grand Valley none of the third-brood larvæ transform until the spring of the next year.

TABLE LXXXI.—*Percentage of codling moth larvæ wintering, Grand Junction, Colo., 1915.*

Brood.	Number of larvæ—			Per cent transforming in 1915.	Per cent wintering.
	Leaving fruit.	Transforming in 1915.	Wintering.		
First	909	432	477	47.52	52.48
Second	1,858	20	1,838	1.08	98.92

Season of 1916.—The percentage of transforming and wintering larvæ of the first, second, and third broods reared in the insectary is given in Table LXXXII. As shown therein, 766 larvæ, or 74.15 per cent, of the first brood transformed; 267 larvæ, or 25.85 per cent, wintered. With the second brood, 170 larvæ, or 6.71 per cent, transformed and 2,362 larvæ, or 93.29 per cent, wintered. There were 328 third-brood larvæ, all of which wintered.

TABLE LXXXII.—*Percentage of codling moth larvæ wintering, Grand Junction, Colo., 1916.*

Brood.	Number of larvæ—			Per cent transforming in 1916.	Per cent wintering.
	Leaving fruit.	Transforming in 1916.	Wintering.		
First	1,033	766	267	74.15	25.85
Second	2,532	170	2,362	6.71	93.29
Third	328	0	328	0.00	100.00

LASPEYRESIA POMONELLA (L.) VAR. SIMPSONII (BUSCK).

During the course of the codling-moth studies, the light buff colored variety of the codling moth known as *Laspeyresia pomonella* (L.) var. *simpsonii* (Busck) was bred from material collected in the field.

REVIEW OF SEASONAL-HISTORY STUDIES OF THE CODLING MOTH IN 1915 AND 1916.

A generalized review of the seasonal-history studies of the codling moth is given graphically in figures 17 and 36 for the seasons of 1915 and 1916 respectively. The curves represent approximately the beginning, ending, and crest of activity of the more important biological stages of the insect.

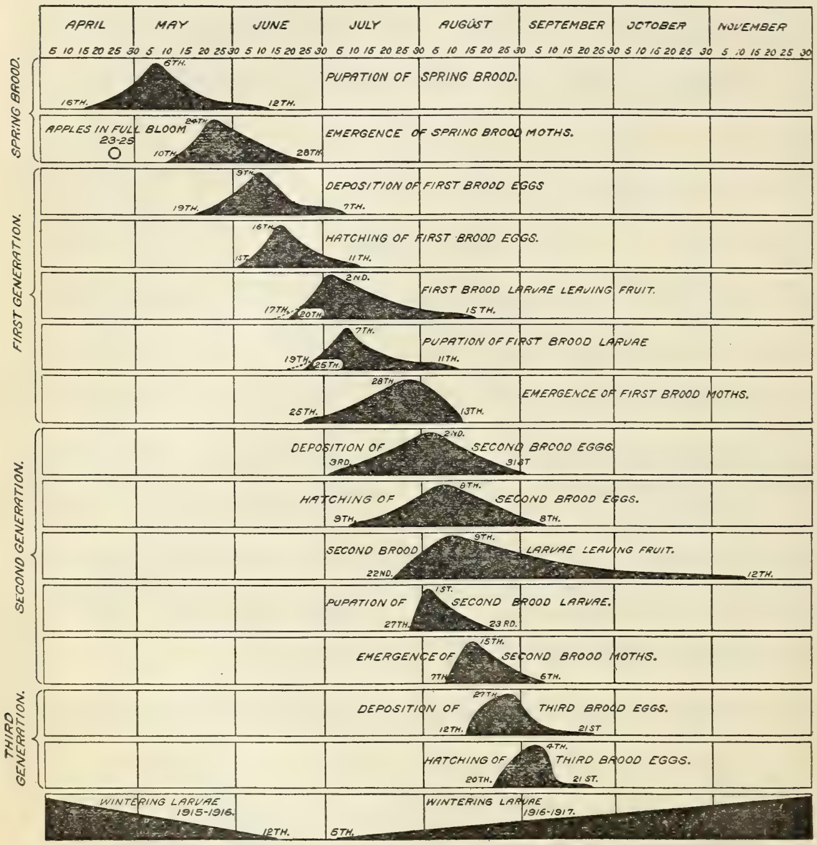


FIG. 36.—Diagram of life history of the codling moth in the Grand Valley of Colorado, 1916.

Pupation of spring brood.—In 1915 pupation commenced April 14, reached its maximum May 12, and ended June 8; in 1916 the earliest pupation took place April 16, was at its height May 6, and ceased June 12.

Emergence of spring-brood moths.—The first moth of the spring brood (1915) emerged May 12, the maximum emergence occurred May 24, and the last moth of this brood issued June 29. In 1916 the first spring-brood moth appeared May 10, the maximum emergence took place May 24, and the last moth issued June 28.

Deposition of first-brood eggs.—The spring-brood moths just referred to were employed in the oviposition studies. The earliest deposition of eggs of the first brood in 1915 occurred May 15, the greatest number of eggs was deposited on June 10, while the last egg was laid July 8. In the following year, the first eggs were deposited May 19, the crest of deposition was reached June 9, and the oviposition period ended July 7.

Hatching of first-brood eggs.—Hatching of first-brood eggs began in 1915 on May 27, and the eggs were hatching in largest numbers June 17. The last of the eggs hatched July 13. Hatching of first-brood eggs the next year commenced June 1, and on June 16 the eggs were hatching in maximum numbers, while the last of the eggs hatched on July 11.

First-brood larvæ leaving the fruit.—The time of larvæ leaving the fruit refers only to the insectary-reared individuals. In 1915 the first of these larvæ left the fruit June 21, on July 20 the largest number of larvæ made their exit from the apples, and on August 10 the last first-brood larva completed its feeding. According to the observations in the field, the first larvæ were collected in the Edwards orchard June 22 and in the Hamilton orchard June 28. In 1916 the first of the insectary-reared larvæ left the fruit June 20, the largest number left the fruit on July 2, and the last larva of this brood left the fruit August 15. But in the field the larvæ left the fruit at least three days earlier as shown by collections made in the Edwards and Hamilton orchards on June 17.

Pupation of first-brood larvæ.—The time of pupation of the first-brood insectary-reared larvæ in 1915 was as follows: First pupation June 27, maximum pupation July 6, last pupation August 4; in 1916 the first pupation took place June 25, the maximum pupation occurred July 7, and the last larva transformed on August 11.

Emergence of first-brood moths.—The time of emergence of first-brood moths as indicated in the diagrams refers to the moths that transformed from the field-collected larvæ. In 1915 the first moths of this brood (Hamilton orchard material) issued July 10, the maximum emergence occurred August 9, and the theoretical limit of emergence was August 19. In the following year all of the moths from the transforming larvæ collected in the Hamilton and Edwards orchards were used for oviposition purposes. The first of these moths issued June 25, the maximum emergence occurred July 28, and the theoretical limit of emergence was August 13.

Deposition of second-brood eggs.—Eggs of the second brood were first deposited in 1915 on July 12, on August 14 they were laid in maximum numbers, and on September 15 the last eggs were deposited. In 1916 the earliest deposition occurred July 3, the maximum deposition on August 2, and the deposition period ended August 31.

Hatching of second-brood eggs.—Eggs of the second brood (1915) commenced hatching July 19 and were hatching in maximum numbers August 21. The last eggs of this brood hatched September 24. In the following year the first eggs hatched July 9, and the largest number August 8. The hatching of this brood of eggs ceased September 8.

Second-brood larvæ leaving the fruit.—The data for these curves were taken from insectary-reared larvæ, and as shown in the graph the first larvæ left the fruit in 1915 on August 5. The larvæ left the fruit in largest numbers September 1, while the last larva of this brood completed its feeding period November 11. In 1916 the first larva emerged from the fruit July 22, on August 9 they left the fruit in maximum numbers, and the last larva of this brood made its exit from the fruit on November 12.

Pupation of second-brood larvæ.—Larvæ of the second brood (1915) began to pupate August 12. The last transformation took place October 2. In the succeeding year the pupation was as follows: First July 27, maximum August 1, last August 23.

Emergence of second-brood moths.—According to the insectary-reared material of 1915, the moths of the second brood commenced to issue August 23. The emergence ended October 14. During the season of 1916 the emergence period extended from August 7 to September 6, with the maximum of emergence occurring August 14.

Deposition of third-brood eggs.—The eggs of the third brood deposited in 1915 failed to hatch. The first egg was laid September 16, the last September 23. In 1916, however, fertile eggs were deposited, the oviposition period extending from August 12 to September 21 with the maximum deposition August 27.

Hatching of third-brood eggs.—None of the third-brood eggs from insectary-reared material hatched in 1915. In the following year the hatching period commenced August 20 and ended September 21. On September 4 the third-brood eggs hatched in greatest numbers.

Wintering larvæ.—The last of the wintering larvæ of the season of 1914 pupated June 8, 1915. The first larva taken in the field during the season of 1915 to pass the winter successfully and transform the following year to the adult stage was collected July 11 in the Edwards orchard. In 1916 the last wintering individual pupated June 12. Since no observations of the time of emergence of moths were taken in 1917, it is impossible to state just when the first wintering larvæ appeared in 1916. The part of the graph referring to the wintering larvæ of 1915–16 should be considered as an approximate estimate only.

SUMMARY.

The life-history studies recorded herein were made in the Grand Valley of Colorado during the seasons of 1915 and 1916.

The climate of the Grand Valley is comparatively dry and warm during the summer season, and is very favorable to the development of the codling moth.

According to the data secured in these studies, there are two complete generations and a partial third generation of the codling moth in the Grand Valley.

Length of the pupal stage of the spring brood.—In 1915 the length of the pupal stage of the spring brood averaged 27.58 days, the maximum was 34 days, and the minimum 15. In 1916 the average was 26.80 days, the maximum 36, and the minimum 13.

Oviposition by moths of the spring brood.—In 1915 the average number of days before oviposition was 6.19, the maximum 19, and the minimum 2; the average number of days for the period of oviposition was 13.82, the maximum 33, and the minimum 1; the average number of days from the date of emergence to the date of last oviposition was 19.14, the maximum 37, and the minimum 5. In 1916 the average number of days before oviposition was 6.07, the maximum 13, and the minimum 2; the average number of days for the period of oviposition was 13.38, the maximum 32, and the minimum 1; the average number of days from the date of emergence to the last oviposition was 18.46, the maximum 34, and the minimum 7.

Number of eggs per female moth of the spring brood.—According to the oviposition studies of the spring-brood moths of 1915, the average number of eggs per female moth was 12.59; in 1916, 11.34 eggs.

Length of life of moths of the spring brood.—In 1915 the average length of life of the male moths was 14.59 days and of the female moths 15.86 days; the maximum length of life of the male moths was 36 days and of the female moths 39 days; the minimum length of life of the male moths was 1 day and of the female moths 1 day. In 1916 the average length of life of the male moths was 14.67 days and of the female moths 15.73 days; the maximum length of life of the male moths was 35 days and of the female moths 39 days; the minimum length of life of the male moths was 1 day and of the female moths 1 day.

THE FIRST GENERATION.

Embryological changes and length of the incubation period of first-brood eggs.—The embryological changes in the eggs of the first brood and the length of the incubation period were as follows: In 1915 the average number of days from the date of egg deposition

to the time of the appearance of the red ring was 2.70, the maximum 9, and the minimum 1; the average number of days from the date of deposition to the black-spot stage was 6.62, the maximum 13, and the minimum 4; the average incubation period was 9.14 days, the maximum 15, and the minimum 6. In 1916 the average number of days from the date of deposition to the appearance of the red ring was 2.62, the maximum 10, and the minimum 1; the average appearance of the black spot from the time of egg deposition was 6.68 days, the maximum 11, and the minimum 5; the average incubation period was 7.32 days, the maximum 14, and the minimum 6.

Length of feeding period of the first-brood larvæ, stock-jar method.—During the season of 1915, the length of the feeding period averaged 21.64 days, the maximum was 35, and the minimum 12. In the following year the average length of the feeding period was 20.19 days, the maximum 42, and the minimum 14.

Length of feeding period of the first-brood larvæ, bagged-fruit method.—The records in 1915 give an average feeding period of 22.77 days, a maximum of 35, and a minimum of 15. In 1916 the average feeding period was 21.10 days, the maximum 29, and the minimum 17.

Length of cocooning period of larvæ of the first brood.—As shown by the observations in 1915, the average cocooning period was 6.70 days, the maximum 28, and the minimum 1. In the following season the average cocooning period was 5.53 days, the maximum 30, and the minimum 2.

Length of pupal stage of the first brood.—The average length of the pupal stage, first brood, in 1915 was 11.44 days, the maximum 31, and the minimum 6; in the succeeding year the average length was 11.23 days, the maximum 19, and the minimum 6.

Oviposition by moths of the first brood.—As shown by the studies in 1915, the average number of days before oviposition was 2.07, the maximum 5, and the minimum 1; the average number of days from the first to the last oviposition was 16.78, the maximum 25, and the minimum 7; the average number of days from date of emergence to last oviposition was 17.85, the maximum 26, and the minimum 10. The summarized data for 1916 are as follows: The average number of days from the date of emergence to the first oviposition was 2.21, the maximum 5, and the minimum 1; the average number of days from the first to the last oviposition was 12.69, the maximum 20, and the minimum 1; the average number of days from the time of emergence to the last oviposition was 13.63, the maximum 20, and the minimum 5.

Number of eggs per female moth of the first brood.—The moths of the first brood of 1915 deposited 46.73 eggs per female moth. In the following year the female moths deposited an average of 43.98 eggs.

Length of life of moths of the first brood.—In 1915 the average length of life of the male moths was 11.86 days, the maximum 41, and the minimum 1; the average life of the female moths was 12.68 days, the maximum 35, and minimum 1. In 1916 the summarized figures give 13.12 and 12.20 days as the average length of life of the male and female moths respectively. The maximum life of the male moths was 38 days and of the female 26 days; the minimum length of life of both the male and female moths was 1 day.

Life cycle of the first generation.—The average life cycle as obtained by rearing individuals from the egg to the adult stage, stock-jar feeding method, in 1915 was 49.30 days, the maximum 72, and the minimum 38. According to the bagged-fruit feeding method, the average life cycle was 49.18 days, the maximum 74, and the minimum 36. To obtain the complete life-cycle add 2.07 days, which was the average time from the emergence of the moths to the deposition of the first egg. In 1916 the average life cycle, stock-jar feeding method, was 44.89 days, the maximum 77, and minimum 36; and the average complete life cycle, obtained by adding 2.21 days to the life cycle, was 47.10 days. The average life cycle, bagged-fruit feeding method, was 46.37 days, the maximum 66, and minimum 38. The average complete life cycle was 48.58 days.

THE SECOND GENERATION

Embryological changes and length of the incubation period of second-brood eggs.—In 1915 the average number of days from the deposition of the egg to the appearance of the red ring was 1.85, the maximum 4, and the minimum 1; the average time for the appearance of the black spot was 5.54 days, the maximum 8, and minimum 3; the average incubation period was 7.22 days, the maximum 11, and minimum 6. In the next year the average appearance of the red-ring stage was 2.06 days after egg deposition, the maximum 3, and minimum 1. The average appearance of the black spot was 5.80 days, the maximum 7, and minimum 5. The length of the incubation period averaged 6.93 days, the maximum 10, and minimum 6.

Length of feeding period of second-brood larvæ.—The average length of the feeding period in 1915 was 28.69 days, maximum 67, and the minimum 15. In 1916 the average length of the feeding period was 28.61 days, the maximum 70, and the minimum 14.

Length of cocooning period of larvæ of second brood.—In 1915 the average length of the cocooning period was 9.35 days, the maximum 31, and minimum 3. In the following year the average number of days for the construction of the cocoon was 4.80, the maximum 14, and minimum 2.

Length of pupal stage of second brood.—The average length of the pupal stage of the pupæ of the second brood in 1915 was 15.62 days, the maximum 31, and the minimum 11. In 1916 the average length of the pupal stage was 13.51 days, the maximum 16, and the minimum 11.

Oviposition by moths of the second brood.—No oviposition data were obtained in 1915 owing to the fact that the eggs deposited by the moths of the second brood failed to hatch. In 1916 fertile eggs were deposited, but since moths emerging on different dates were confined in the same cages no oviposition data were obtained.

Number of eggs per female moth of the second brood.—In 1915 no fertile eggs were deposited, but in the following year the average number of eggs per female moth was 45.58.

Length of life of moths of the second brood.—The moths of the second brood of the seasons of 1915 and 1916 were not confined in separate cages according to their time of emergence. For this reason no data were obtained.

Life cycle of the second generation.—The life cycle of the second generation in 1915, as determined by rearing, was as follows: Average length of incubation period 6.12 days, average larval feeding period 20.49 days, average cocooning period 8.56 days, average pupal period 15.62 days, and average life cycle 50.81 days. In 1916 the records show that the average length of the incubation period was 6.01 days, the average larval feeding period 18.08 days, the average cocooning period 4.78 days, the average pupal period 13.52 days, and the average life cycle 42.40 days.

THE THIRD GENERATION.

Embryological changes and length of the incubation period of third-brood eggs.—In 1916 the average number of days from the date of deposition to the appearance of the red ring was 2.49, the maximum 5, and the minimum 2; the average number of days from the date of deposition to the appearance of the black spot was 6.36, the maximum 9, and the minimum 6; the average incubation period was 7.77 days, the maximum 11, and the minimum 7.

Length of feeding period of third-brood larvæ.—The average larval feeding period of the third-brood larvæ in 1916 was 37.55 days, the maximum 68, and the minimum 20.

PERCENTAGE OF TRANSFORMING LARVÆ.

Percentage of transforming larvæ of the first brood.—In 1915 47.52 per cent of the first-brood larvæ transformed, while in the following season 74.15 per cent pupated.

Percentage of transforming larvæ of the second brood.—In 1915 1.08 per cent of the second-brood larvæ transformed. In 1916 6.71 per cent of these larvæ transformed.

Percentage of transforming larvæ, band material.—In 1915 the percentage of larvæ collected in the field in connection with the band studies that transformed to the adult stage was 45.37, and in 1916 40.88.

MISCELLANEOUS.

Natural enemies.—The following predators were recorded: A small beetle, *Tenebroides corticalis* Melsh., and a spider, *Coriarachne versicolor* Keys.

The following parasites were observed: *Trichogramma minutum* Riley, *Dibrachys clisiocampae* Fitch, and *Arthrolytus apatelae* Ashmead. The predacious and parasitic enemies play a very unimportant rôle in checking the codling moth in the Grand Valley.

The emergence of moths from fruit cellars is later than that in the field. The period of emergence in fruit cellars, however, is shorter than that which obtains under field conditions.

The majority of the moths of the spring and first broods emerge during the latter part of the morning and early part of the afternoon.

The codling moth is believed to be a nonmigratory species except for short local flights. The moths have, however, strength to fly in a continuous flight, unaided by the wind, for a distance of at least one-half mile.

The codling moth is most active in depositing her eggs late in the afternoon to early in the evening, the activity being greatest just about dusk.

The fecundity of the codling moth in the Grand Valley is high. Three female moths of the first brood deposited in confinement over 300 eggs each, the highest total deposition by one moth being 316 eggs, 115 being the largest number deposited in one day by a single female.

The codling moth larva normally cuts its way through the eggshell and emerges head first. Occasionally it will protrude the anal end first, but in this case it is sometimes unable to extricate itself.

An examination of a pear orchard devoid of fruit revealed the fact that codling moth larvæ will sometimes burrow into the new growth, resulting in the browning of the foliage.

The codling moth larva prefers to spin up under dark-colored bands.

The buff-colored variety of the codling moth known as *Laspeyresia pomonella* (L.) var. *simpsonii* (Busck) was reared in the Grand Valley.

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